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BUSH-SICKNESS INVESTIGATION.

FIVE YEARS' WORK AT THE MAMAKU DEMONSTRATION FARM.

B. C. ASTON, F.I.C., F.N.Z.Inst., Chemist to the Department.

INTRODUCTION.

THE Mamaku Farm was purchased by the Department of Agriculture in 1912 for the purpose of studying the obscure malnutrition or deficiency disease in domestic ruminants which occurs in an extensive area of pumice land in the Lake district of the North Island, and to some extent on the lands which lie between that district and the coast. This trouble, which manifests itself as progressive anaemia, is variously known to the settlers as "bush sickness," "bush disease," or "the skinnies." The latter is the most graphic name, as it precisely conveys the ultimate condition at which animals arrive after a few months' sojourn on the luscious-looking pasture, chiefly red and white clovers and cocksfoot, of the region under review. Previously the Department owned no farm in the bush-sick area on which experiments could be carried out, but had relied on certain leased areas at Lichfield, Mamaku, and Te Pu on which temporary experiments in grazing were conducted (See *Journal* for November, 1912, April, 1913, and June, 1913). Mamaku, it may be mentioned, is situated fourteen miles north-west of Rotorua, on the railway-line.

For the present Mamaku Farm, at first 305 acres were acquired of land which had been tawa-rimu forest, but a considerable portion of which had been felled, burnt, and surface-sown by the original owner, Mr. R. A. Jackson. A further 212 acres were purchased in 1920, making a total of 517 acres. Mr. Jackson had purchased the "bush" or forest some twenty-eight years before, and had felled about 200 acres and grassed it for a first clearing. Every year subsequently, for some years, he had felled, burnt, and grassed some 80 acres, surface-sowing it with a seeding of 30 lb. of cow-grass and cocksfoot mixture per acre. Good logs were sold to the local sawmill, and the owner also carried on a butchery business, from which his main income was derived. As showing the effects of the disease, it may be here stated that no farmer in this district who relied upon his farm alone for a living and who had no other business but farming had been able to carry on. Those who survived had had some business to financially assist their farming activities, or some farm outside the bush-sick area on which to change their stock.

At the time of taking the farm over there was only one small paddock adjacent to the homestead which had been logged up and ploughed. Since then and up till 1919 some 20 additional acres had been logged up, ploughed, and cropped. Experiments had been laid down to ascertain the effect of top-dressing the surface-sown pastures with various artificial manures and soil amendments such as lime, and subdivision of the paddocks into smaller areas had been carried out, some 168 acres being thus divided into eleven paddocks of various sizes. Experiments had been conducted in the medicinal treatment of cattle with drenches, licks, and medicated drinking-water, and in pasturing stock on paddocks variously top-dressed compared with those which received no dressing. The experiments were carried out with both sheep and cattle. A supply of water had been assured by the construction of tanks peculiar to this country, made by hollowing out elevated necks of soft volcanic rhyolitic breccia rock, giving the pit thus dug a coating of Portland cement, and erecting round its sides an iron roof—a reservoir which effectively collected and retained the water in this region of copious rainfall. The sites of these tanks were so well situated above the general level of the farm that the water could be piped off to every paddock. The tanks hold, when full, some 16,000 gallons. Root crops had been grown and meadow and oaten hay stored for winter feed. Up to this time (1919) it had been amply demonstrated by experiments at leased sites and at the Mamaku Farm that top-dressing the old surface-sown pasture led to a very great improvement in its feeding-quality, and, when phosphate was the dressing, of its quantity also. The writer may here be pardoned for a brief digression which may help to throw some light on a difficult aspect of the problem.

It seems obvious that both grasses and clovers can and do flourish on this bush-sick country; they go through their life-cycles perfectly, growing to a good size and producing fertile seed. Top-dressing with phosphate enormously increases the yield of clovers and leguminous plants, and a general improvement of pasture-condition may be noticed after such treatment. The only manurial ingredient the pasture-plants profit by, so far as they are concerned, is phosphates.

That this is not sufficient for the animal grazed is evidenced by the fact that it cannot remain healthy on such improved pasture for longer than a year or two years. What is sufficient to the plant is evidently insufficient for the animal. If the pasture be top-dressed with an iron salt the result is to decrease the clovers and hence reduce the carrying-capacity. The net result, however, is that stock can be carried longer on this pasture than on any other, because they can remain healthy on iron-dressed pasture longer in spite of the decreased quantity of herbage. The pasture of bush-sick country evidently either takes up from the soil too much or too little of some substance, or else elaborates some poison, for it is clear that such green pasture does not, as it should, supply the requirements of the animal.

It is to arrive at the practical method of combating this discrepancy that the necessity arises for a demonstration farm conducted along lines which the man with average capital, experience, and ability can follow. With a view to diminish the cost of running such a farm it has been decided to try and make as much profit as possible by farming in the old-fashioned way with such country—namely, to buy stores, improve them in the limited time they can be carried before showing signs of sickness, and sell them at a profit; further, to try side lines such as horses, pigs, poultry, bees,* &c., with the idea of increasing the chances of survival of the settler, who would certainly succumb were ruminants in this country the sole class of stock and the method of farming the ordinary one. Thus the operations of this demonstration farm may be divided into experimental and profit-making, and until a new treatment is proved an economic success it is not proposed to try it on more than a few animals at a time, thus restricting any loss as much as possible.

It may therefore be taken as effectually proved that up to the year 1919 the only improvement in the general farming of the district that had been demonstrated as feasible was the efficacy of phosphate dressings, firstly, in increasing the carrying-capacity, and, secondly, in enabling stock to be kept healthy for a longer period than if phosphates were not applied. On the profit-making part of the farm the stock are therefore part-time grazed on paddocks which have been liberally treated with a phosphate dressing. Such a progressive innovation has, however, not been generally adopted by the farmers in the immediate vicinity. They are evidently awaiting the ultimate results of the demonstration farm before taking any steps which may prove only an alleviation but not a cure. Numbers of landowners on the Mamaku Plateau are at present holding on to their properties, paying rates, &c., but not improving them. They are apparently merely marking time until a definite official pronouncement of how to farm these lands is issued, as the result of the Mamaku Demonstration Farm operations. A cessation of the demonstration farm's activities, in the absence of such a pronouncement, would be construed into a confession that Mamaku land could not profitably be farmed, and lead to an abandonment of holdings and fall in land-values.

So far in this article only mature stock have been referred to; another aspect of bush sickness is that young stock cannot be raised

* So far provision has been made for pigs only.

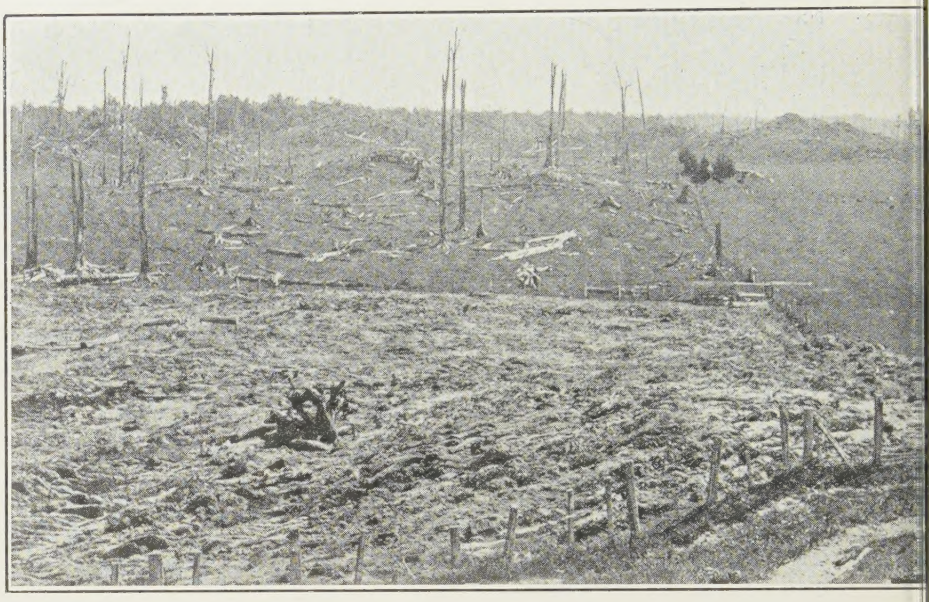
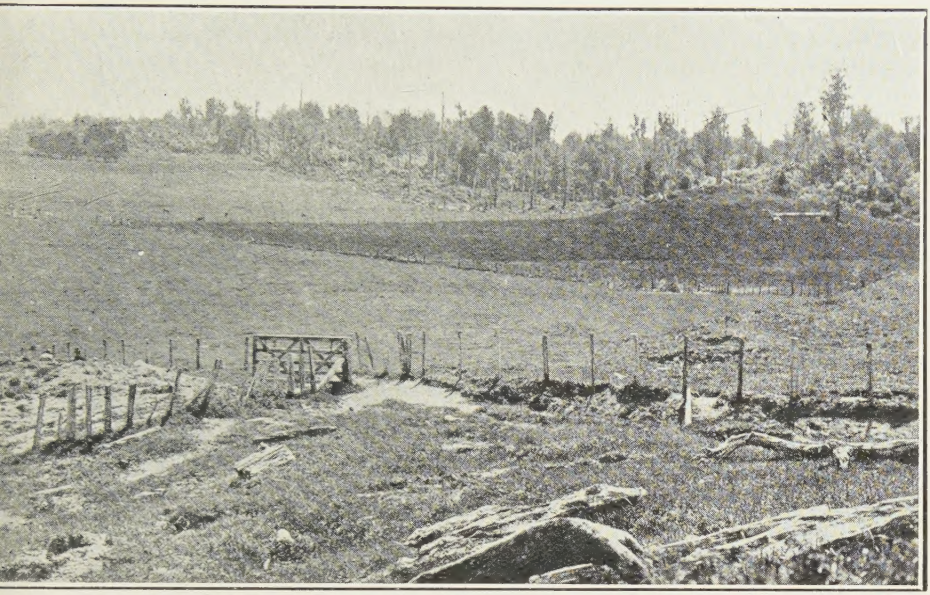


FIG. 1. GENERAL VIEW OF TH

The stages in the conversion of this class of country into arable land ar a scenic reserve which separates the farm from the Rotorua Railway line. I which results from the surface-sowing of a bush-burn. This stage ordinaril under the plough for the first time, the stumps having been blown out with hig only completed in November last, when the photo was taken. A fine crop o which has been down some years after cropping with roots.

beyond the weaned stage. This is a general statement ; the truth probably is that in the worst areas neither lambs nor calves can be reared, while in other districts only calves can be raised but never lambs. At Mamaku Farm, which was typical of the most bush-sick class of land, considerable progress had been made up to the year 1919 in delaying the mortality in weaned calves by the aid of organic iron salts and artificial feeding—the period at which they could be kept alive on grass had been lengthened. Indeed, two heifers ("Mary" and "Jane") had been successfully raised to maturity, had given birth to several calves, and had been milked; but their progeny had in all cases died ultimately, although one survived nine and another twelve months. These heifers were, however, the outstanding exceptions. Born on the farm in 1914, after their first calves were born the dams were kept alive by unremitting attention involving constant supply of iron (as inorganic salt-lick), almost continuous drenching with iron phosphate, pasturing on a paddock recently top-dressed with superphosphate, and, lastly, administration of Ferri. Ammon. Cit. (commercial), which had the most effect of all the treatments. Finally they were sent to Tirau for a good spell of six months in 1922, brought back to Mamaku (where they put on condition very fast for the first time without medicine), and sold as beef in January, 1923. In the majority of cases, no matter



MAMAKU DEMONSTRATION FARM.

hown in the photograph. On the extreme right is a belt of tawa-rimu forest, he foreground and background is the pasture growing among stumps and logs asts from ten to twenty years. In the left middle foreground is seen the land xplosive and drawn together and burnt. The ploughing of this paddock was urnips is now growing as a first crop. In the right middle foreground is pasture

[*All photos by B. C. Aston.*

how healthy the calves seemed up to eight or nine months, they could not be reared to the yearling stage, the exceptions being only occasional.

Turning now to the experience with sheep, it may be premised that this ruminant is by far the more susceptible to bush sickness, and can be carried on bush-sick pasture for relatively a much shorter period than cattle. The Mamaku country, with its heavy rainfall, high elevation, and rush of rank pasture in the early summer, is not what one would recognize as typical sheep-country; and, descending to the particular, this farm is by no means well situated for sheep-farming. It is rather too close to a large settled area, the paying industry of which is sawmilling. The attentions of dogs have proved a constant source of anxiety, and losses out of every lot of sheep carried have been sustained from this cause. On one occasion eighteen were killed in one night. For sheep, the boundary-fences of a large area have necessarily to be kept in better order than for cattle; hence, on this and on other accounts, the experiments at Mamaku have mainly been confined to cattle. The outstanding fact, however, had been demonstrated, that sheep may be kept for two years on pasture top-dressed with iron-salts. Every sheep-farmer will realize the difficulty in keeping the same sheep in the same paddock for two years for experimental purposes, and the

difficulties were very much greater when, as in this case, the paddock was in a rough stumpy condition and in a back part of the farm difficult to supervise. In the second year it was seen that the iron compounds had had a marvellous effect in keeping this more susceptible ruminant healthy, a result which was merely a confirmation of the Lichfield and Martin's paddock (Mamaku) experience with sheep on pasture dressed with iron salt.

THE PAST FIVE YEARS' WORK.

We now arrive at the date at which this article takes up the history of the experiments. The Department is now in possession of a rough bush-farm, with a working manager and an assistant resident on the premises, about one mile from a prosperous sawmilling township and railway-station. To the eye the country is very suitable for cattle; although at 1,800 ft. elevation, grasses and clovers grow well most of the year. The surface is flat with the exception of the volcanic mounds or necks which in many places project through steep grassed slopes, forming rocky outcrops of great value to the district for roadmaking and for the construction of the elevated tanks already mentioned. Creeks are few and far between on the Mamaku Plateau. Where shallow watercourses do occur they soon disappear into one of the crevasses which seam the country. Hence provision for watering cattle must be artificially contrived. This rhyolitic rock underlies the surface soil, which is composed of coarse pumice, air-borne from the distant mountains or, more probably, from the enormous extinct crater on which now stands the town of Rotorua. After stumping the land is eminently suitable for cultivation and for the growth of winter feed, the swede crop being exceptionally good and free from disease. The rapid and continuous growth of pasture in all but the three months of winter, the abundant and well-distributed rainfall, the porous soil, the absence of all swamps, and the possibility when the country is brought under the plough of growing ample winter feed (root crops and hay), the proximity of good roads, a railway-station within a mile, and two dairy factories eight miles distant by rail—are all factors indicating the possibility of dairying as the most profitable utilization of the country after the sawmill has taken its toll of timber from the land. Operations during the last five years have been largely directed towards proving the possibility of dairying on this type of country, which, if successful, may reasonably be expected to substantially increase the present value of the land.

PERMANENT IMPROVEMENTS.

Since 1919 some 35 acres have been stumped, ploughed, and sown in turnips and other crops, and subsequently laid down in grass. The main access to the farm, a private road from the main Mamaku Road, has been logged up and planted on each side with trees. On paddock No. 9, near the homestead, a site has been excavated, and permanent farm-buildings, consisting of office, man's room, combined implement, wool, and trap shed, and pigsties have been erected. This building replaced a dilapidated barn and slaughterhouse, the good timbers of which were utilized in the new building. The whole of this work was accomplished by the Farm Manager (Mr. Jackson) and his assistant,

with the aid of a local carpenter. A fence was erected round the farm-buildings, and concrete bails, yard, and shelter for the calves constructed. On wet days during 1921 gates for the farm were constructed. The homestead has been thoroughly renovated and made confortable. . Portions of shelter-bush trees near the homestead have been ring-fenced. Fences on the home paddocks have been repaired with posts split on the farm. The stockyards have been put in thorough repair with totara posts cut on the farm. A large paddock near the homestead has been made pig-proof, and it is proposed to use it for experimental pig-farming. Crevasses on the farm, peculiar to this plateau, have been ring-fenced and planted to prevent stock falling in.

CROPPING, ETC.

Every year since 1919 some 16 acres have been devoted to root crops, Crimson King and Superlative swedes being favourites. The manuring for these has been from 3 cwt. to 4 cwt. of phosphates per acre, basic super being the chief ingredient. It is significant that on a portion of land which had previously been limed by top-dressing, a Chewings fescue paddock (No. 5), two good crops of turnips were obtained in consecutive years, superior to those on land which had not been limed. In this paddock, contrary to the general experience, the land was found to be full of earthworms. Liming evidently has a good influence on the turnip crop, although its effect on bush-sick pasture is not apparent for some years, and animals pastured on newly limed areas become bush-sick quicker than on the untreated pasture.

Large quantities of meadow hay have been saved each year. The quantity is usually about 20 tons, but this year there is about 30 tons available for the winter. In addition, oaten hay (10 tons in 1923) and oats and vetches have been saved. There are now about 65 acres of well fenced, stumped, and cultivated paddocks available for cropping, 120 acres of surface-sown pasture in rough stumpy condition which has been improved by phosphatic top-dressing, and 262 acres in rough surface-sown pasture which has not been improved by top-dressing. The remainder of the farm area, 70 acres, is in standing bush (tawa forest).

PROFIT-MAKING.

As is well known, during the last few years the beef-market has become unprofitable, while dairying has prospered. It is, however, inadvisable to launch out into dairying on the Mamaku Farm until it is proved conclusively that this branch of cattle-farming can be successfully carried out on a large scale there without periodically resorting to changing the cows on to healthy country. It will take a few years to prove whether this can be done, and seasonal and other uncontrollable factors must be guarded against by not placing too great a reliance on one or two years' favourable results. It has therefore been decided that only a maximum of about a dozen cows shall be used as the experimental dairy herd. Seeing that this is essentially cattle-country rather than sheep-country, the only two avenues of revenue from cattle are somewhat narrowed, and one must not be despondent if on the profit-making section of the farm no great profit can be shown. The farming operations for the period under review

have been therefore almost entirely restricted to the grazing and fattening of store cattle. Stocking has, of course, been necessary to prevent deterioration of the pastures where so much is in the rough stump condition, and where the land is liable to be invaded by noxious weeds, particularly blackberry and ragwort, from adjacent infested areas.

In 1919 129 store sheep were bought at 16s. and sold fat three months later for 30s. Twenty cows after being nine weeks on 8 acres of turnips all did well, one half being fat; thirteen bought in June for £7 sold at £11 in September. Eighty-one steers bought for £7 to £11 each sold for £9 to £10. Eight cattle were sold off turnips at satisfactory prices. In 1920 a mob of 141 ewes was purchased at Morrinsville in June; only eighty proved to be in lamb; they did well up to about two months after docking, and that was the time when normally they should have been sold. It was decided, owing to the statements that the sickness was disappearing as the country grew older and that top-dressing should make a considerable difference in the time that sheep might be kept, to hold the ewes for a longer time, in order to test these theories. They could not be sold until 15th December. By this time, owing to bush sickness and to the attacks of dogs, the sheep had gone back considerably, twenty-two being lost. The mob originally cost £161, and the sheep were sold for £173. Both the wet ewes and the lambs went back most, but fifty-three of the stronger-constitutioned ewes held their own and fetched 25s. 6d. Eighteen made 23s., and seventy-seven (with lambs in) 22s. This was a useful experience, and therefore worth recording, although an unprofitable operation. No doubt more sheep-grazing would improve the pastures as well as provide a good profit. A considerable outlay on fencing for subdivision and improvement would, however, be necessary.

In 1921 sixteen fat bullocks were sold at the Hamilton sale, topping the market at £9; eight made £8 4s. net, eight £7 net, and three more were disposed of locally. On 21st May forty two-year-old steers (bought 6th October, 1920) were sold at £7 2s. 6d. In December two hundred grazers (yearling heifers) were taken in at 6d. per head per week and yielded a net profit of £80. In June eleven fat cows were sold, six at £3 2s. and five at £1 10s.

In 1922, in August, twenty heifers sold at Matamata sale for £5 each, a profit of about £1 per head. In September one heifer sold at Tirau for £6 5s. In October twenty-six head of stock were disposed of, prices for some of the springing culled cows being fairly good. The heifers fetched only poor prices. Six pigs sold for £2 10s. per head at Putaruru.

In 1923 sixteen bullocks, which cost £3 13s. per head, were sold in April at the Claudelands sale for £4 18s. Fifty good-conditioned two-year old heifers purchased in February, 1922, made a gross profit of £30, which was not sufficient for handling them; twelve proved to be empty. They were on the farm only five months, and had turnips and hay; notwithstanding this they lost condition after being on the farm six weeks, and were in low condition when sold. Thirty-one store cattle wintered well and brought a profit of £1 10s. each. In May another truck of fat cattle were sold to the butcher for £4 17s. 6d.

each. In June sixty-four cattle were sold at Morrinsville sale at £4 1s. One hundred and five three-year-old steers, costing £3 13s. 3d. each in the spring of 1923, were disposed of by selling forty at £4 1s.; others were sold later, but the price was a poor one considering the good condition the animals were in. Thus bad markets in this case nullified what should have been a successful grazing operation. After November, 1923, fifty-six store steers were disposed of.

In 1924 twenty-four cattle were sold at £7, and eight at £5; twenty-three others were also sold, a total of forty-seven disposed of.

These extracts from the farm reports do not represent a prosperous condition of things, but the handling of these stock provided valuable experience, and, in addition to the small profit, supplied the means of "carrying on" and improving the pasture and gaining additional experience in working the country.

FIG. 2. SOME COWS OF THE EXPERIMENTAL HERD AT THE MAMAKU FARM.
From left—"Brindle," "Polly," "Darkey," "Daisy," "Cherry." Photo taken in February last.

So as not to be entirely dependent on ruminants, it is proposed in the coming year to determine what can be done in pig-farming, although even this must be limited in scope until demonstrated beyond doubt not only that it will pay (of which there is very little doubt) but that the food produced under the conditions of this peculiar type of country is such that the grazing of pigs can be successfully carried out on a large scale. There appears to be considerable hope for this new industry in the district. Not only is pig-raising to a certain extent complemental to the dairy industry through securing a profitable use for skim-milk, but the soil is more particularly adapted to the growing of several important fodder crops suitable for pig-feed than is the soil of non-pumice districts. If pigs are not affected in any way by the factors which cause bush sickness—and there is

no evidence that they are so affected—the great growth of clovers, which are merely induced by top-dressing with phosphates, and the splendid disease-free crops of potatoes, mangolds, artichokes, and other potash-loving crops which this highly potassic, easily worked soil produces are good augury for successful pig-farming on a large scale.

There are other branches of farming, such as horse-raising, poultry-keeping, and fruit-farming, which might be tried in order to settle this country, but in all these branches it is necessary to feel the way and not launch out too ambitiously at first. Hence in the profit-making section we must be content with small returns for some years. It may be mentioned here that bush sickness does not attack horses. A few good sorts have been bred on the farm since the Department took it over. Before this Mr. Jackson had as many as forty brood mares, which proved quite a successful proposition.

EXPERIMENTAL.

The last article on the bush-sickness investigation published in the *Journal* appeared in the issue of April, 1919, when the curative method of treatment by means of iron salts was described. It was then shown that the syrup of phosphate of iron was a cure for bush-sick cattle, and that organic salts of iron such as the double citrate of iron and ammonium (Ferri. Ammon. Cit. of the druggist) were similarly efficacious, and hence could replace the syrup. Iron tartrate was also effective in the limited number of instances in which it was tried. Acetate of iron was tried but not continued. Lactate of iron for some reason was not found to be of any value as a curative agent.

Two new methods of medicinal treatment have been experimented with at some length, and will be recorded in the following pages. The success gained by the use of syrup of phosphate of iron might be attributed to the joint effect of the three ingredients—iron, sugar, and phosphoric acid—or to the single effect of any one of these three. Phosphoric acid given medicinally has proved to be useless for keeping cattle free from the sickness. The application of phosphates to the pasture, although it improved the quality and quantity of herbage, did not enable stock to be kept permanently healthy, yet it lengthened the period during which the stock could be kept on the farm without a change to healthy country or other remedial treatment. The use of sugar in the syrup may have had some influence in effecting a cure when acting jointly with the other ingredients, but in one experiment in which sugar and another in which sucrosine was tried each of these substances failed to act as a preventive.

A farmer, Mr. Norman Callister, of Te Puke, in April, 1920, kindly communicated his experience in the use of molasses, from which it would appear that this may also be a cure for bush sickness. Molasses is such a mixture of plant products that it is hard to say to what constituent of the mixture the good effects may be due. Molasses is a by-product in the manufacture of sugar, and would contain a large amount of inorganic material originally present in the sugar-cane. The discovery that molasses is a partial cure is, however, an exceedingly interesting one, and great credit is due to Mr. Callister for placing his experience unconditionally at the disposal of the Department.

It must not be lost sight of that should molasses be found to be an absolute economic cure it will not help much in solving the problem of finding the ultimate cause of bush sickness. It will merely emphasize what is know already—that plants, or what is in this case a concentrated extract of plant-juices, grown on any other soil than that of a bush-sick area will when fed to stock effect a recovery of bush-sick animals. Stock which go away in a bush-sick state to pasture in clean country, even to a paddock which is so bare that the animals still keep their lean condition, apparently store up something which enables them to become fat after they are returned to the pasture upon which they originally became bush-sick. The writer believes that this substance which is so stored up is iron, which is, as is well known, accumulated in the liver, the spleen, and the bone-marrow. Unfortunately, lack of the requisite specimens has prevented any

FIG. 3. OTHER COWS OF THE EXPERIMENTAL HERD.

From left—"Ginger," "Blot," "Daisy," "Roanie," "Melba," "Lily." Photo taken in November last.

demonstration of the proof of this theory. It is well known, however, that the foetal ruminant animal stores up iron in its body and derives little of it from the milk of its mother after birth. The growing necessity for a further supply of iron forces the young calf to eat grass, and it is just at this stage that the calf in the bush-sick region becomes sick unless iron is supplied in its milk or in some artificial food, when its health is prolonged.

With regard to the efficacy of the double citrate of iron and ammonium as a remedy, it will be seen that there are here three constituents—iron, ammonium, and citric acid. It can hardly be the citric acid which is the effective agent; citric acid and tartaric acid probably exist in all pastures in plenty. It has been proved by lick experiments that ammonium chloride exercises no preventive influence in keeping stock free from the sickness. One is therefore forced to the conclusion that iron in the assimilable state is the prime factor in effecting a cure when such is accomplished by the means of ammonium and iron citrate. The rather important but not quite intelligible discovery has been made that when the iron and ammonium citrate is

prepared in the laboratory by merely warming lemon or limejuice with freshly prepared ferric hydrate until it dissolves, and subsequently adding enough ammonium to form the double salt in solution, this home-made solution is far quicker in its action than the bought "crystals" (which latter are merely scales). It will be observed that the bulky solution has not been concentrated or even boiled. The vitamine enthusiasts will probably offer the explanation that the lemon-juice supplies vitamines, whereas the commercial Ferri. Ammon. Cit. does not; but in answer to this, if lack of vitamines is to be in any way held responsible for bush sickness the present conception of vitamines must be greatly enlarged. At present one cannot learn of any instance in which ruminants fed on mixed green pasture have been proved to suffer from lack of vitamines.

Another factor which has proved highly instrumental in keeping stock free from bush sickness is the winter feeding with turnips, another food which the said enthusiasts will quote as having a high vitamine content. The turnip is a great storer of phosphates, and the ash of turnips is differently balanced from that of grasses and comparatively rich in iron.

MEDICINAL AND OTHER TREATMENT OF DISEASED COWS.

Following are detailed notes of the treatment and effects on experimental milch-cows for four years. All of these cows came from the Morrinsville district.*

"*Nigger,*" seven-year-old Friesian cow. Arrived at farm 27/10/20; calved 29/4/21. Was given ½ lb. linseed in locally grown chaff twice daily from 27th May, also hay and turnips. At 31st July was looking and milking well, giving 4 gallons per day. At 30th August was going off in milk, giving only 3 gallons; at 30th September the milk had decreased to 2½ gallons; at 18th October was giving 2 gallons; at 1st November was going bush-sick, only 11 lb. per day; so on 14th November, having fallen away considerably, the cow was taken to the change paddock at Tirau (on healthy country). The cow was brought back from Tirau on 3/3/22 quite recovered and had put on great condition. On 19th June she was found lying dead in a position which suggested heart-failure—no apparent cause.

"*Darkie,*" Friesian, dehorned eight-year-old cow. Arrived 6/7/21; calved 29th July. On 5th September commenced to feed ½ lb. linseed and 3 lb. local chaff twice daily. At 1st October was improving in condition, giving 26 lb. milk daily; at 1st November milk increased to 30 lb. daily, and cow looking well. Artificial feeding had to be discontinued on 15th November, as there was too much grass and she would not take the linseed. At 30/1/22 cow was looking well, giving 20 lb. milk; at 28th February was still in good condition, and giving 15 lb. milk. At 30th March feeding with linseed was recommenced, cow now giving 11 lb. milk. On 30th April the milk was reduced to 8 lb. On 1st May the cow was rugged and hay was fed to her in paddock. When still well, on 12th June, she was dried off and commenced to run on turnips two hours each day. She was looking well till 31st July, having been receiving linseed 30/3/22 to 31/7/22. At 31st August, cow, being in good condition, was springing, and calved on 25th

* The locality whence imported stock are derived exercises a great influence on their subsequent health at Mamaku, and the relative resistance which they offer to the disease. Mr. Gamman, of Tauranga, has given the Department some valuable information with regard to his experience in using cattle obtained at as great a distance as possible from the bush-sick area. Animals purchased by him in large numbers from the Marton district have proved to be remarkably immune when transferred to bush-sick country. This aspect will be further investigated at Mamaku.

September; calf apparently had been dead for some time. Cow still getting hay and turnips, but giving very little milk. At 31st October cow was at a standstill, giving only 15 lb. milk daily. In November cow refused to take artificial food readily, perhaps on account of abundance of fresh feed. Every sign of bush sickness present. At 30th November stopped treatment owing to abundance of fresh feed. The cow was at a standstill or going back slightly, giving 10 lb. milk daily. On 6th December commenced to drench with potassium iodide solution, 1 fl. oz., with a teaspoonful of salt added, once a day; on 22nd December finished drenching with iodide, which effected no change. At 1/1/23 no improvement noticeable.

On 15th January commenced to drench with citrate of ammonium and iron made from Cook Island limes, 3 fl. oz. twice a day. Stopped drenching on 8th March, cow showing signs of improvement, and being milked once a day. Recommenced drenching with 3 fl. oz. of commercial Ferri. Ammon. Cit.. The improvement continued to 20th May, when the drenching was stopped, the cow having much improved.

On 20th May commenced feeding with local chaff and 1 lb. molasses twice a day, and gave turnips and hay from 1st July in addition to chaff and molasses mixture. The improvement was maintained, and at 1st September she was springing to calf. On 15th September the molasses was reduced to once a day, but the full daily dose of 2 lb. was maintained in locally grown chaff. The turnips were now finished, but the molasses treatment was continued up till the date she calved—16th September—quite naturally, the calf being strong and healthy and the cow in first-rate condition. This cow therefore has had every kind of treatment, and the net result is that at the time of writing (March, 1924) both the cow and calf (a brindle bull calf) are still in excellent condition.

"*Te Kuiti*," a grade Jersey cow, four years old. Arrived at farm 22/3/22; calved 6th October, when in first-rate condition. Commenced feeding on 2 fl. oz. of iron and ammonium citrate made from Cook Island limes, with 3 lb. of locally grown chaff, twice daily. At 31st October she was giving 3 gallons of milk, and the citrate medicine was stopped, as she refused to take the dry chaff when there was such an abundance of green feed. She continued in excellent condition, and was giving 22 lb. milk on 1/1/23, and 20 lb. at 1st February. At 1st March she was noticed to be dull about the eyes but still in good condition; weight of milk, 15 lb. At 1st April she was losing condition, thought to be first signs of bush sickness. At 1st May she was going back quickly and giving only 7 lb. milk, being milked once daily. On 20th May commenced feeding 2½ fl. oz. of the commercial iron and ammonium citrate in local chaff twice daily. At 1st June, in addition to medicine, she was getting hay and turnips. At 1st July a slight improvement was noticed; the cow was rugged, as the weather was extremely severe. At 1st August she was looking much better, and was getting much turnips and hay. At 19th August she slipped her calf and was too far off to come to milk. At 1st September she was slowly improving, still getting medicine in chaff, and turnips and hay fed out to her. It had been stopped to enable another treatment to be tried, but as the medicine for this did not come to hand she was put back on to the Ferri. Ammon. Cit. By 15th September she improved, and went to the bull 20th. On 15th October she was improving quickly and the medicine was stopped. She is now in good condition.

"*Cherry*," Ayrshire-Hereford crossbred cow, six years old. Arrived at farm 5/9/20; calved 1st November. Milking well, giving 5 gallons a day. Commenced giving 2½ fl. oz. Ferri. Ammon. Cit. twice daily in 3 lb. of local chaff. At 17/9/21 was milking once a day, giving about a gallon and looking well, showing no signs of sickness. On 14th November, as this cow had gone bush-sick and no improvement could be effected, she was taken to the Tirau paddock, and brought back on he 4/3/22. She slipped her calf when away. She was in good condition on 1st May and went to the bull. On 30th November she was again going bush-sick fast, giving only ½ gallon of milk. On 6th December commenced to drench with 3 fl. oz. of iron and ammonium citrate, home-made from Cook Island limes. On 25th December drenching was stopped, as she had improved in condition and was giving 1½ gallons. On 15/1/23 the treatment was recommenced, giving 3 oz. twice daily, which was stopped on 13th February, as the cow had further improved and was giving 2 gallons. Recommenced to drench with 3 fl. oz. of iron and ammonium citrate on 15th March, and she steadily improved in condition and continued to give 2 gallons till 4th May, when the medicine was stopped, the condition of the cow being fully restored, with a daily yield of 1 gallon of milk.

On 20th May a treatment of molasses was commenced, given in local chaff twice daily. This cow was now in a fair condition. At 1st June she was getting hay and turnips. At 1st August the molasses treatment was still being given, with hay and turnips in plenty. Her condition was now stationary or, if anything, going back. She was still giving 6 lb. of milk a day. This treatment was continued until 15th September, when all the turnips were finished, and the molasses and chaff treatment was reduced to once a day, a slight improvement being noticed. On 17th October she calved, the calf being strong and healthy but a little thin. On 22nd October she was giving 37 lb. milk, and on 31st 45 lb. At this time she was getting 3 lb. of molasses per day, and this was continued until 10th November, when the molasses treatment was discontinued, the cow milking well and slowly putting on condition. At 26/3/24 condition good; milking well; again in calf.

"*Brindle*," a dehorned seven-year-old Jersey-Shorthorn. Arrived at the farm 6/7/21; calved 8th August. At 5th September molasses treatment with local chaff was commenced twice daily. At 1st November she was giving 15 lb. of milk and improving in condition. At 1st November giving 40 lb. milk; at 15th the molasses was stopped owing to there being too much grass. At 13/1/22 she was giving 35 lb. and at 28th February 22 lb. At 30th March she was yielding 15 lb., and the molasses treatment was recommenced. At 30th April giving 10 lb. of milk. On 1st May she was rugged, and feeding on meadow hay commenced. At 12th June, when still looking well, she was run on turnips two hours each day. On 1st September, having had the molasses regularly since 30th March, she calved, the calf, a white-faced Hereford bull, being strong, and the cow in excellent condition. At 27th September the cow was giving 45 lb. of milk daily. At 31st September, 50 lb. milk, with the cow still in excellent condition. She went to the bull on 18th November. At 30th November, the cow being in excellent condition and giving 45 lb. of milk, supplementary feeding was stopped, there being abundance of pasture and the animal not taking dry food readily. At 30th December she was giving 40 lb. milk; at 30/1/23, 35 lb.; 1st March, 20 lb.; 1st April, 15 lb. daily. At 18th April feeding with molasses in local chaff once a day was recommenced. All this time the cow had been in excellent condition, and she was dry on 25th May. On 1st June hay and turnips were given, and continued with molasses treatment till 15th September, when instead of getting the ration of 1 lb. twice a day she got it once a day in local chaff, and the turnips were discontinued. On 15th October, her condition having been first-rate all along, molasses feeding was stopped. She calved on 4th November, the calf, a bull with a little brindle on back, being strong and healthy. At 10th November she was giving 50lb. milk. At 10/3/24 weight of milk 31 lb. daily; condition good; again in calf. This cow is therefore in the unique position of having raised two healthy calves on the Mamaku Farm without a change to healthy country.

"*Roanie*," six-year-old light roan Shorthorn. Arrived 6/7/21; calved 20th August. Commenced feeding 2 lb. bran in 3 lb. local chaff, twice a day. At 1st October found to be not improving like other cows, giving 24 lb. of milk. At 1st November was improving and giving 28 lb. of milk. At 15th November had to stop feeding bran owing to abundance of green feed. At 30/1/22 looking well and giving 15 lb. of milk. At 30th March commenced to feed bran again; giving 12 lb. of milk; at 30th April, 9 lb. At 1st May started on meadow hay, and rugged with sack up to 8th June; was looking well, and aborted at seven months. At 12th June commenced to run on turnips two hours daily; was losing condition at 31st July, but was being milked once daily only right through the winter. The bran treatment had been continued since 30th March. At 31st August the cow was losing condition, taking food erratically, and continued to go back till 31st October, when she was moved to the Tirau paddock for a change. On 17/3/23 she was brought back in fair condition, which she maintained till 20th May, when she was given 2 lb. molasses in local chaff daily. She was in good condition at 1st June, when hay and turnips were supplied. On 4th August she slipped her calf, and was too far off to come to milk. On 15th September, the good condition having been maintained all through, the molasses was reduced 2 lb., being given only once a day in local chaff. This was discontinued on 15th October, the cow being then in very good condition.

Four cows had no special treatment at first, but were given turnips and hay in winter.

"*Maud*," a Shorthorn crossbred red-and-white four-year-old cow. Arrived at farm 6/6/21; calved 26th August, and gave some trouble in calving, calf being

born dead. Gave only 3 pints of milk at 6th September; improved and gave more milk up to 15th October, when the flow decreased and was reduced by 30/4/22 to 6 lb. At May she was rugged, and was dry by the 30th. She was put on turnips for two hours daily and continued looking well and in good condition until 30th September, when first signs of bush sickness were manifested in dry coat. About 18th October calf again born dead, and cow went back in condition and gave very little milk. Went to Tirau paddock on 2nd November for change, as coat was rough, flanks hollow, and eye dull. She was brought back from Tirau on 1/4/23, looking well, and improved considerably within a month of coming back to the old pasture.

At 20th May commenced feeding 1 lb. molasses in local chaff twice daily. This was continued with plenty of turnips. On 15th September, her condition being still good, the molasses was reduced to once a day, 2 lb. in local chaff, all the turnips being finished. The cow calved 25th October, the calf being strong and healthy. At 31st October she was in good condition but not giving much milk (one quarter being dry), only 20 lb.; finished feeding molasses. At 10/3/24 condition still good; giving 16 lb. milk daily; apparently in calf.

"*Daisie*," Shorthorn four-year-old light roan. Arrived at farm 6/7/21; calved 15th September. At 1st October giving 41 lb. milk; 1st November, 42 lb.; 31/1/22, 32 lb.; 28th February, 20 lb.; 30th March, 15 lb.; 30th April, 10 lb. At 1st May rugged and given meadow hay. At 15th May looking well and being milked once a day. Commenced feeding turnips, two hours each day. Has looked well all the time, and at 31st October was in excellent condition and springing. Calved on 19th November; at 30th November giving 40 lb. milk; looking better than when she calved last year, but not milking so well. At 1/2/23 condition good, but a little dry in coat; giving 30 lb. milk. At 1st March giving 25 lb.; put to bull on same date. Giving 2 gallons at 1st April. Put to bull again 5th May. Going back in condition, although on hay and turnips; remained in stationary condition to 30th September, getting hay and turnips all the time, when an improvement was noticeable, eye brighter and better skin. At 30th October was looking well. On 1/1/24 gave birth to strong healthy calf. Cow in good condition, but not milking so well. At 10th March giving 24 lb. milk daily. Apparently again in calf, still healthy.

"*Brier*," grade Shorthorn, dehorned, six years old. Arrived 6/7/21; calved 15th October (calf died 21/3/22). Giving 40 lb. milk and improving at 1st November; 30 lb. at 30/1/22; 18 lb. at 25th February; 16 lb. at 30th March; 12 lb. at 30th April. At 1st May rugged and started on meadow hay; at 15th May looking well and milking once a day. Started running on turnips two hours a day. At 30th June was looking well; dry on 31st August; was found to be empty, but in excellent condition. At 1/1/23 looked well, but appeared stiff all over and developed a curious stiff-necked habit when feeding. Although in excellent condition, was slaughtered and found to be suffering from spinal tuberculosis.

"*Lily*," light roan Shorthorn, dehorned, seven years old. Arrived 6/7/21; calved 15th October. At 1st November was giving 35 lb. milk, and in good condition; 30 lb. at 30/1/22; 20 lb. at 28th February; 18 lb. at 30th March; 12 lb. at 30th April; 12 lb. at 1st May, when rugged with sack cover and started on meadow hay. At 15th May was milked once a day. At 12th June was run on turnips two hours a day, and progressed well until 15th July, when appeared tucked up in stomach. Continued in the same condition until 17th October, when she calved; calf dead. Cow going back fast, with first signs of bush sickness; giving 12 lb. of milk on 31st October. Was moved to Tirau on 2nd November and brought back in good condition on 17th March. On 25th March was served by bull, and by 1st May had greatly improved since being brought back from Tirau.

On 20/5/23 commenced giving 2½ fl. oz. iron and ammonium citrate in local chaff twice daily, the cow being in good condition. At 1st June was getting in addition hay and turnips. On 15th September commenced to feed once a day, instead of twice, 3 fl. oz. of Ferri. Ammon. Cit. in local chaff; finished feeding turnips At 30th August cow was in first-rate condition; at 15th October finished feeding out medicine, the animal being beef. At 1/1/24 cow calved, a good strong calf. At 10th March, milk 27 lb. daily; apparently again in calf.

"*Ginger*," bright-yellow Jersey six-year-old. Arrived 6/6/21; calved 25th September. At 1st October giving 34 lb. milk, and had improved in condition; at 15th October, 30 lb. At 16th October commenced to drench with phosphoric acid, 30 c.c. daily. Finished drenching at 24th December for a time;

cow doing well. At 28/2/22 cow looking well, and giving 15 lb. milk. At 30th March 12 lb. milk, when commenced to feed locally grown chaff with a daily dose of phosphoric acid mixed with it. At 30th April looking well and giving 10 lb. milk. Was rugged and given meadow hay at 1st May. At 15th May was looking well; dry. At 12th June was given turnips for two hours each day. Looking well up to time of calving, 23rd August. Calf weakly and not expected to live, and was destroyed. Cow continued in good condition, but during September lost condition, although still getting turnips and hay with medicine and chaff, which she took readily; giving 25 lb. milk. At 31st October gave 30 lb. milk, but showed signs of bush sickness. At 1st December was stadily losing condition; stopped feeding medicine, as she would not take it readily; giving 22 lb. milk.

Commenced giving potassium iodide twice daily, mixed in table-salt, 1 oz. with salt making eight doses. On 22nd December left off drenching, as no improvement effected and animal continued to go back in condition; giving 15 lb. milk at 1/1/23.

Commenced at 15th January to drench with 3 fl. oz. of iron and ammonium citrate, made from Cook Island limes, twice daily. At 1st March cow had not improved in condition much, but milk increased in quantity, milking once a day giving 15 lb. Commenced drenching with 3 fl. oz. of the commercial Ferri. Ammon. Cit. twice daily. Started to improve in condition at 15th April. At 9th May improving, and milking once a day. At 20th May commenced giving 2½ fl. oz. Ferri. Ammon. Cit. in local chaff twice daily; cow improving daily at 1st June. Getting hay and turnips; still slowly improving at 20th June. Later quite recovered from bush sickness, and getting plenty of hay and turnips. At 15th September commenced giving 3 fl. oz. of commercial Ferri. Ammon. Cit. in local chaff once a day; turnips finished. At 15th October condition was good; finished feeding out the medicine. Due to calve again in May this year. At present in perfect health.

"*Rose*," a red-and-white Shorthorn six-year-old dehorned cow. Arrived on farm 6/7/21; calved 3rd October. Improved in condition and gave 6 lb. of milk at 1st November, 30 lb. at 30th November. At 10th December started to drench with phosphoric acid, 30 c.c. daily, which was finished at 24th, when she was looking well; but doubtful if this was due to good food or to medicine. At 28/2/22 she was giving 15 lb. milk and looking well. At 30th March she was given 30 c.c. of phosphoric acid in about 6 lb. of locally grown chaff, then giving 13 lb. milk, which was reduced to 10 lb. during April. On 1st May she was rugged with a sack and started to feed on meadow hay, and on 15th she was milking well once a day. On 12th June she started to run on turnips two hours each day. At 30th June she was dry and looking well. At 15th July she started to scour, so medicine was stopped for a few days. She was now falling away in condition and not cleaning up her feed. At 31st July she was still scouring, dull about the eye and not looking well. At 31st August she had recovered from the scouring, but exhibited every appearance of commencing bush sickness. At 27th September there was no doubt of this cow being bush-sick. She refused to take her medicine. At 8th October had trouble in calving; took dead calf away on 9th. On 10th cow died through condition being impaired by bush sickness.

"*Melba*," spotted Ayrshire Shorthorn twelve-year-old. Arrived at farm 6/7/21; calved 21st December with twin calves, dead. At 1/1/22 giving 30 lb. milk; at 1st February improving in condition and giving 40 lb. At 28th looking well and giving 25 lb. At 30th March looking well but not putting on as much condition as other cows; giving 20 lb. At 30th April losing condition a little; giving 10 lb. At 1st May rugged and fed on meadow hay. At 31st looking well and milking once a day. At 12th June commenced running on turnips two hours a day and did well up to 15th July, when she was falling away slightly and continued milking once a day. Weather rough. Cow empty. At 27th September cow dry, and appeared to be losing condition, although still feeding on hay and turnips until 31st October, when she was showing signs of bush sickness. At 2nd November she was taken to the Tirau paddock, and brought back on 17/3/23, looking healthy but not in good condition. At 1st April she was improving, and at 1st May looking well. At 20th she was given 2½ fl. oz. of Ferri. Ammon. Cit. scales in local chaff twice daily, and was then in fair condition; her condition had never been really good. At 1st June she was getting turnips and hay, but her condition was still only fair; this was continued to 15th September, when commenced to feed medicine once a day instead of twice, and the turnips were finished. Medicine

was finished on 15th October. She was still in the same state at 30th, never having put on condition in spite of five months' medicine. At 4/1/24 calved; calf strong and healthy; cow a wreck, and died on 12th from old age and bush sickness.

"*Queenie*," Jersey dehorned seven-year-old. Arrived at farm 6/7/21. At 5th September was given 1 lb. of molasses in 3 lb. of local chaff twice daily. At 1st October she was improving in condition and giving 33 lb. milk. At 1st November she was looking well and giving 42 lb. At 15th molasses feeding was stopped, as there was too much grass for her to take the dry food. At 30/1/22 she was looking well and giving 30 lb. milk; at 28th February, 15 lb. At 30th March commenced feeding her again with molasses, getting 13 lb. milk; at 30th April 6 lb. At 1st May she was rugged with sack cover and started to feed on meadow hay. At 31st she was dry; appetite not so good; still taking molasses in dry food but inclined to leave it. At 12th June commenced running on turnips, two hours each day. At 30th she refused to take any food with molasses in it. At 15th July was losing condition; at 31st eyes dull, hollow flanks, signs of bush sickness. This cow had refused to take molasses and chaff about the middle of June, since when she had it only at intervals three days a week. The ration of molasses was reduced from 1 lb. to ½ lb. daily in order to induce her to take it. At 31st August the cow refused to take the molasses, and was rapidly falling away at 30th September, although still taking turnips and hay. At 15th October she calved; the calf was too weak to live, and the cow died.

"*Polly*," a dark Jersey eight-year-old dehorned cow. Arrived at farm 6/7/21; calved 14th August; calf born dead. At 5th September commenced feeding 2 lb. bran in 3 lb. local chaff twice daily. At 1st October was improving and giving 32 lb. milk. At 1st November looking well and giving 40 lb. At 15th, there being too much grass, stopped feeding. At 30/1/22 she gave 30 lb., and at 28th February 20 lb. milk, and was looking well. At 30th March the bran feeding was recommenced; now giving 12 lb. milk. At 1st May she was rugged and started on meadow hay; at 31st milking once a day. At 12th June commenced running on turnips two hours daily; at 30th she was dry and looking well. At 31st August she was still looking well, but backward in springing. At 30th September was in excellent condition, and at 30th October springing a little and still in excellent condition. At 30th November stopped feeding bran. At 20th December cow calved; calf strong and healthy; cow in excellent condition. At 1/1/23 not milking quite as well as previous year, although in better condition, giving 25 lb. milk. At 1st February was losing condition and showing first symptoms of bush sickness; giving 25 lb. milk. At 1st March slowly going back in condition; giving 20 lb. At 15th March commenced drenching with 3 fl. oz. of commercial Ferri. Ammon. Cit. twice daily. At 1st April condition was improving. At 20th May commenced giving 2½ fl. oz. Ferri. Ammon. Cit. in local chaff twice daily; cow showing slight improvement. At 1st June getting hay and turnips; not much change in condition. At 1st July little improvement; at 1st August looking a little brighter; at 1st September improving in condition. At 15th September feeding reduced to once a day—that is, 3 fl. oz. of commercial Ferri. Ammon. Cit. in local chaff. Turnips by now all finished; at 30th September improvement maintained. At 18th October cow calved; calf thin and weakly. At 23rd October milk yield was 18 lb.; at 31st 29 lb. At 10th November finished feeding on Ferri. Ammon. Cit.; cow now in really good condition and completely recovered from bush sickness. At 10/3/24 yield of milk 23 lb. daily; condition first rate; again in calf.

NOTE.—The dosage of commercial Ferri. Ammon. Cit. is in each case given as fluid ounces of a 6-per-cent. solution of the scales. In the case of the home-made citrate solution, different lots of which varied somewhat in strength, the dose specified was in each case equivalent to 2 fl. oz. of the 6-per-cent. solution above-mentioned.

TREATMENT OF CALVES.

Spring of 1921.

Three of the calves of the before-mentioned cows were all given the following treatment: 1 gallon of new milk night and morning for the first fortnight; ½ gallon of skim-milk in ½ gallon of whole milk

for the next fortnight, night and morning; ½ lb. meal (4 lb. barley-meal, 2 lb. bran, 1 lb. linseed) fed in the milk for the next three weeks; and then ½ lb. meal fed dry after having had milk, with ¼ lb. molasses added. The calves were weaned at about six months and put on young grass. In other calves the treatment was varied by omitting the molasses. At the time of weaning the three calves which had had molasses were quite the best of the ten treated, there being little difference between the other seven. All of this season's calves, however, were found to be affected with lungworm, and all died at various dates subsequently.

Spring of 1922.

The calves born alive in the spring of 1922 were as follows: Dam "Brindle" (second calf)—a white-faced Hereford bull, 1st September; dam "Te Kuiti"—a fawn Jersey heifer, 6th October; dam "Daisy"—red bull, 19th November; dam store heifer—Shorthorn - Jersey heifer, 20th August.

These calves were given the following treatment:—

"Brindle's" second: 1 gallon of milk for first fortnight, night and morning; ½ gallon whole and ½ gallon skim milk for next fortnight; 1 gallon skim-milk and ½ lb. mixed meal (made as above) scalded and fed in milk for next two months; and then had ½ lb. meal daily with ¼ lb. molasses after having milk. He was turned out on to new grass when weaned, about six months.

"Te Kuiti's" calf was given the same treatment as "Brindle's" second calf, but had crushed oats instead of mixed meal, and no molasses. At 10th May a little Ferri. Ammon. Cit. scales was given in milk twice daily up till 30th September, when the treatment was discontinued.

"Daisy's" and the store heifer's calves were given exactly the same treatment as "Te Kuiti's." The condition of all these four yearlings was good at February, 1924, when the photo (Fig. 4) was taken.

Spring of 1923.

These (Fig. 5) calves had the usual milk treatment—whole milk during the first month; an equal mixture of skim and whole milk in next month; and then a special treatment additional to the mixed milk as described for each calf.

"Brindle's" third calf; born 4th November; strong red Shorthorn bull with a little brindle on back; ¼ lb. molasses per day added to the milk.

"Polly's" third; born 20th October; a thin weedy red heifer with white legs; 1 fluid ounce of iron and ammonium citrate (home-made) per day added to the milk.

"Darkie's" third; born 16th November; a strong brindle Shorthorn bull; same treatment as "Polly's" calf.

"Cherry's" third; bull with white on face; born 17th October; strong and healthy; ½ oz. iron and ammonium citrate (commercial) per day to milk.

"Maud's" third; heifer, partly brindle; born 28th October; strong and healthy. Control.

"Daisy's" third; born 1st January, 1924; strong and healthy light roan heifer. Control; no treatment to milk.

These treatments were still being carried out at 26th March, 1924.

FIG. 4. YEARLINGS FROM COWS SOME YEARS ON FARM, PREVIOUSLY UNSUCCESSFUL IN REARING CALVES.

The white-faced calf is "Brindle's" second calf; the Jersey heifer, "Te Kuiti's" second; the red-and-white bull, "Daisy's" second; the Shorthorn-Jersey on far side of fence is the "store heifer's" calf. Photo taken in November last.

FIG. 5. SOME OF THE 1923–24 SEASON'S CALVES.

Those in the foreground, reading from left, are out of "Polly," "Darkey," "Cherry," "Maud," and "Brindle." Photo taken in February, 1923.

Six calves from new cows are at date of writing between six and seven months old, and all healthy (see Fig. 6): (1.) Dam "Fanny"

—white bull; good strong constitution; no treatment to the milk. (2.) Dam "Jean"—one bull, in centre of photo with back to camera, and one on extreme right, dam "Mona" (both showing signs of scouring), are calves on molasses treatment to the milk, ¼ lb. night and morning, are in better condition than any of the three lots; weaned 1st February, 1924. (3.) Dam "Spot," calf on left, and dam "Beauty," calf on right, the two other calves facing camera, are on citrate-of-iron treatment and are in good condition; they had ½ fl. oz. home-made Ferri. Ammon. Cit. in milk, night and morning. (4.) Very small calf (behind white calf) refused to take milk and is dwarfed. N.B.—The rest had whole milk for two months instead of one.

At the time of taking the photo—February, 1924—the white calf was in the poorest condition, although when born she was the strongest. "Spot's" calf is a little larger, though not in such good condition as the molasses calves. Both weaned 1st February, 1924. "Beauty's" calf is in good condition.

RECORD OF CALVES BORN AT MAMAKU FARM OUT OF EXPERIMENTAL DAIRY COWS.

Dam.	Date Cow arrived on Farm.	First Calf.		Second Calf.	Third Calf.
		Born.	Died.		
"Brindle"	6/7/21	8/8/21	Ten months ..	Survived ..	Survived.
"Brier" ..	6/7/21	15/10/21	Five months ..	Dam killed*	..
"Cherry"	5/9/20	1/11/20	Destroyed at birth	Slipped calf	Survived.
"Daisy" ..	6/7/21	5/9/21	Killed (lungworm)	Survived ..	Survived.
"Darkie"	6/7/21	29/7/21	Eight and a half months	Born dead ..	Survived.
"Ginger"	6/6/21	1/10/21	Seven months ..	Destroyed ..	Not calved yet.
"Lily" ..	6/7/21	15/10/21	Seven months ..	Born dead ..	Calf destroyed at birth; strong.
"Maud" ..	6/6/21	26/8/21	Born dead ..	Born dead	Survived.
"Nigger"	27/10/20	29/4/21	Cow died ..	..	..
"Polly" ..	6/7/21	14/8/21	Born dead ..	Destroyed at 2½ months	Survived.
"Queenie"	6/7/21	..	Calf and cow died	..	..
"Roanie"	6/7/21	20/8/21	Nine months ..	Slipped calf	Slipped calf.
"Rose" ..	6/7/21	3/10/21	Six months ..	Born dead ..	Cow died.
"Te Kuiti"	22/3/22	6/10/22	..	Survived ..	Slipped calf.
"Melba" ..	6/7/21	21/12/21	Twin calves died	Cow empty	Cow died; calf destroyed; healthy.

* Tubercular.

FIG. 6. CALVES BORN IN AUGUST, 1923, OUT OF NEW COWS WHICH ARRIVED AT THE FARM ON 2ND JULY.

On extreme left, calves out of " Spot " and " Beauty " which received citrate-of-iron treatment; red-and-white calves out of " Jean " and " Mona," molasses treatment; white calf out of " Fanny," control. Photo taken in February last.

RETROSPECT.

In considering these experiments with dairy cows one should notice the diverse breeds of the cows employed. Friesian, Jersey, Ayrshire-Hereford, Jersey-Shorthorn, Shorthorn, Ayrshire-Shorthorn, all the common milking breeds and crosses, are here represented, and in the case of " Cherry " there was a considerable strain of a beef breed (Hereford). Regarding the influence of breed on the incidence of bush sickness, in the light of the present limited experience little can be said, but it looks as though the undiluted Shorthorn breed had been rather unfortunate in these experiments. Out of sixteen cows, six were Shorthorn; one of these was slaughtered as tubercular, one died, and one was discarded as unsuitable. Of the whole six only one raised a healthy calf in three years.

Medium-aged cows, from six to eight years, are probably the best to introduce for bush-sick country. Heifers have not enough constitution, neither have aged cows, to withstand the extraordinary conditions.

Regarding the different treatments, it is evident that neither bran nor linseed feeding have had anything more than a temporary effect on the dairy cattle. Linseed puts a good coat on the animal for a time. Bran is also good for a time if enough be given, but its dryness hinders the continuous administration when there is plenty of grass available. After all it is practically a foodstuff imported into the district, very rich in phosphates, and the effect of phosphates has been determined to be at first beneficial. Such foodstuffs given in addition are, of course, remedial to a certain degree if grown on country free from the sickness.

Molasses certainly labours under the same criticism that it is an imported foodstuff of mixed mineral or ash content, but it is a cheap by-product—really a waste product in both the cane and the beat-sugar manufacture—and if larger supplies became necessary they could no doubt be obtained at a greatly reduced price. The method of feeding molasses recommended in Europe is to mix it with hot water and pour the solution over the dry food and well mix the two. Scouring generally follows its use as a food, but Kellner states that it is possible to avoid this by gradually introducing it in increasing quantities to the dry food until the maximum of 2½ lb. for cows, 4 lb. for fattening bullocks and sheep, and 5 lb. for pigs is reached. Animals in an advanced state of pregnancy are said to show a tendency to abortion when molasses is fed. The action of molasses in combating bush sickness in stock may be due to one or all of the following causes: (1) It may act as a food, increasing the general nutrition; (2) it may supply certain mineral foods deficient in the natural ration, or correct the balance of the mineral ration; (3) it may, by its antiseptic or purging effects, alter the digestive mechanism of the ruminant and enable it to assimilate more of the iron present in the pasture, hay, or artificial food.

That molasses has such a benificent influence on bush sickness makes the administration of iron salts a very much easier matter than if drenching were always necessary. The bought iron compound may be dissolved in hot water mixed with molasses and more hot water, and sprinkled on hay or the dry feed. But if a quick recovery is desired the home-made medicine may be made from lemon-juice, precipitated iron hydrate, and ammonia, mixed with molasses, stored, and given as required. In hot weather the diluted molasses may ferment, but in the cooler months fermentation is unlikely at the elevation of Mamaku.

A point that should not be lost sight of is that all those cows which with appropriate treatment in their third year raised healthy calves had lost their calves in the first year, and in the second year all but two had lost them. All these cows (except "Brindle"), which at the time of writing are healthy, have been bush-sick and have been brought round by treatment, so that it cannot be said that anything but the treatment has enabled then to regain their health and to keep it. With regard to "Brindle," a naturally strong-constitutioned cow, her first calf survived to the age of ten months, and it is possible that the dam would have gone bush-sick but for the treatment, in spite of her strong constitution.

The administration of iron and molasses consecutively gave excellent results with "Darkie" and "Cherry" when linseed had previously failed. The iron treatment alone was good in "Te Kuiti's" case, but owing to the treatment being stopped at a critical time she lost her calf. Mr. Jackson thinks that this was owing to the stoppage of the iron treatment. Molasses and turnips were responsible for "Brindle's" excellent performance—two calves in consecutive years, both healthy and surviving, and the dam healthy throughout the whole time. Molasses failed with "Queenie," who refused to take it with her food, but probably was the cause of "Maud's" success after a change. Bran alone was a failure, but after a change molasses enabled a healthy calf to be reared by "Roanie," previously treated with bran. Bran succeeded for a time with "Polly," and enabled her to produce

FIG. 7. COW "BRINDLE," OF THE EXPERIMENTAL HERD.

This animal is outstanding as having healthily reared two consecutive calves (one to the yearling stage) without leaving the farm.

a calf which survived for two and a half months and then had to be destroyed, while the dam had to be brought round by iron treatment, her subsequent calf surviving. Phosphoric acid failed to show any permanent benefit to "Ginger" and "Rose." Turnips and good feeding were no doubt responsible for "Daisy's" freedom from sickness, but failed with "Lily" and "Melba."

From a perusal of these cases it will be seen that the iron and ammonium citrate treatment gives the most positive results, but it is quite likely that with a more extended experience molasses treatment may prove efficacious.

It is, of course, open to objectors to urge that there was something exceptional in the season of 1923–24 which enabled the grass to have greater nutritive qualities. This can only be negatived by continuing the experiments over a term of years, so eliminating seasonal influence.

CURRENT WORK AND PROSPECTS.

Experiments are being conducted with sugar bricks containing the maximum amount of iron and ammonium citrate which it is possible to get an animal to lick. This is a concentrated form of medicine and may be put into the feed-box for the cows to lick during the limited time they are in the bails each day while being milked. Such a lick must, of course, be kept away from the weather, as the sugar is extremely soluble in water (far more so than salt) and would soon be washed away by rain. Cattle show a great avidity for such a lick, which is made up in a pressed form and is extremely hard and dense. Experiments at Mamaku have shown that the difficulty of automatically giving iron in lick form has hitherto arisen from the unwillingness of the animal to partake of the astringent-tasting compound when it is mixed with salt. The difficulty is now likely to be in the contrary direction when used in the open field ; the excessive desire of the stock

to take the sugar lick will have to be combated by mechanical devices, such as a series of lick-boxes so arranged that each animal gets its own share, otherwise the stronger animals will monopolize and consume all the lick.

As to the cost of the iron and ammonium citrate, the price is now much lower; although at one time as high as 16s. 6d. per pound it can now be obtained in 1 cwt. lots in London for 2s. 9d. per pound. Further, this is a case in which an increasing demand would considerably cheapen the supply. The growth of lemons and limes could easily be carried out on a large scale at Tauranga and Te Puke, on the margins of the bush-sick area. Limes contain much more citric acid than lemons. The citric acid is the dearest constituent of the three, being about 2s. 6d. per pound; the ammonia is about 1s. per pound, and the iron a few pence. Thus, if the citric acid (32 per cent.)—the most expensive ingredient to buy—is grown locally, the ammonia (52 per cent.) will be the only expense to seriously consider; this can be obtained for 1s. per pound, and the cost of the iron (16 per cent.) is negligible. Large quantities of citric acid or a salt of this are either manufactured or wasted from surplus or bad fruit in every citrus orchard.

The prospect for the successful utilization of pumice lands now classed as bush-sick would seem to be reasonably bright, but there is much room for careful research work of all kinds—at the Mamaku Demonstration Farm, on the farmer's lands, and at the Chemical Laboratory, at Wellington. The writer has interested the Lands Department in the matter, and a topographical survey of the Rotorua County is in progress, which it is hoped will be extended to the poorer pumice lands beyond that county. A topographical map is of the utmost importance in connection with a soil survey of the district, which is at present being carried out.

The Mamaku Farm has been fortunate in having the management of Mr. R. A. Jackson, the late owner of the property, who has an intimate knowledge of the district, and has always been keenly interested in testing theories concerning bush sickness, and unsparing in his efforts towards finding a solution. Mr. R. Alexander, Stock Inspector, Hamilton, for some years was most instrumental in purchasing stock for the farm when required, and also in exercising supervision over it. Mr. H. Munro, District Inspector, Auckland, has since 1st April, 1921, taken over the supervision, and has been very successful in suggesting and initiating new methods of working. Mr. J. Lyons, M.R.C.V.S., District Superintendent, Auckland, has had the professional supervision of the live-stock, while the investigation as a whole has been under Mr. A. R. Young, Director of the Live-stock Division, Wellington. Under Mr. Young's direction the Mamaku Farm, from being a collection of rather dilapidated sheds surrounded by rough pasture and stumps, has evolved at comparatively small expense into a well-ordered business-like dairy farm, with subsidiary branches and 65 acres of land under crop or temporary pasture.

In next month's *Journal* the writer hopes to deal with the more scientific side of the question, and give some account of the laboratory work.

THE "TURNIP-FLY" AND ITS ASSOCIATES.

"FLY" PROVED TO BE THE GRASS-GRUB BEETLE.

DAVID MILLER, Entomologist, Biological Laboratory, Wellington.

Of the crops most intimately associated with animal husbandry in New Zealand turnips and rape are perhaps the most outstanding and universally cultivated, but they are more or less severely assailed by disease and insect depredations. Among the insect pests one of the great drawbacks to successful turnip-growing is the so-called "turnip-fly," considerable areas of turnips in most parts of the Dominion being annually laid waste during the seed-leaf stage, necessitating one or more resowings of the crops. Prior to the investigation of this problem last spring nothing definite had been established as to the identity and nature of the insect or insects responsible, and the term "turnip-fly" has been universally used by farmers with reference to the trouble.

THE "FLY" AND ITS HABITS.

The reports of damage from various turnip-growing districts of the Dominion showed that most of the loss occurs during November and early December, when considerable areas of turnips are in the first leaf. This pointed to the probability of the grass-grub beetle (*Odontria zealandica* White), notorious for its depredations upon the foliage of various plants such as orchard-trees, willows, &c., being the culprit, since at that period of the year large swarms of the beetle are on the wing. Subsequent observations proved this to be the case, although other factors were found responsible for part of the damage.

The attack of the "fly"—the grass-grub beetle—is confined to the above-ground portion of the plants affected, and practically any crop in the seed-leaf stage during the flight of the beetle is liable to destruction. In many districts the damage to rape is just as serious as to turnips, but the former grows more rapidly and has better chances of recovery. At times the seedling crop is damaged only within half a chain or so of headlands, particularly in the vicinity of hedgerows and tall grass (Fig. 1); but though the beetle is responsible for this to a certain extent it is mostly the work of the cutworm, which will be dealt with later. The characteristic feature of the beetle infestation is that the whole crop is completely destroyed or large patches are eaten out over the whole area (Fig. 2). The injured individual plant shows that the seed-leaves and stalk may be completely destroyed, nothing being left but the underground portion, or one or both of the seed-leaves may be partly or wholly removed from the stalk. The effect of the beetle on crops in full leaf is not so noticeable, as there is more leaf-surface to come and go on, but the attacks are nevertheless apparent, and may even result in more or less complete defoliation. The beetles eat the leaves along the edges, so that the latter, if not destroyed, are noticeable on account of their serrated appearance.

The beetle (Fig. 3), as mentioned, is on the wing during November and the first three weeks of December each year, though it may be active in smaller numbers during the latter part of October and into January.

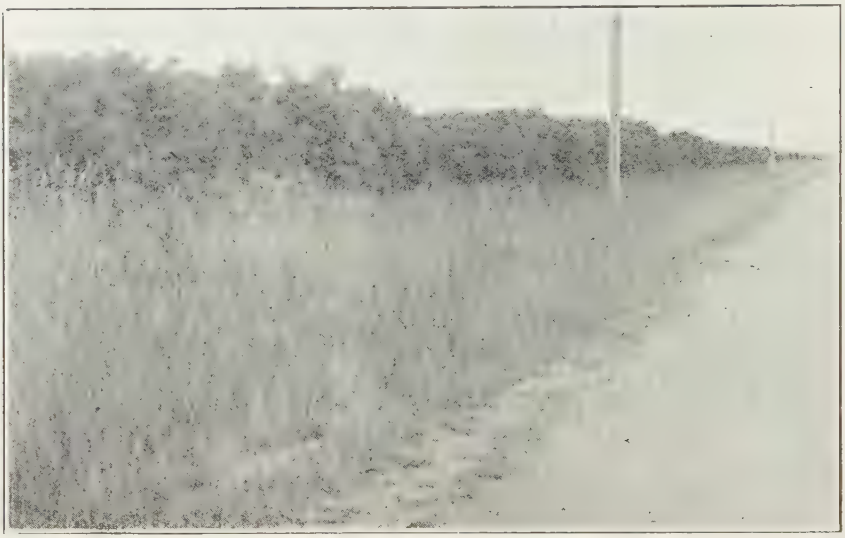


FIG. 1. A CHARACTERISTIC FEATURE OF THE TURNIP-GROWING AREAS: HEDGEROW AND RANK GRASS WHERE INJURIOUS INSECTS SHELTER AND BREED.

FIG. 2. A YOUNG TURNIP CROP AT AMBERLEY ATTACKED BY THE "FLY."

[Photos by F. E. Ward.

FIG. 3 (ON LEFT). GRASS-GRUB BEETLE (ODONTRIA ZEALANDICA)—THE SO-CALLED "TURNIP-FLY." × 2½.

FIG. 4 (CENTRE). GRASS-GRUB—THE LARVA OF O. ZEALANDICA. × 4.

FIG. 5 (RIGHT). PUPA OF GRASS-GRUB. × 4.

[*Photos by E. B. Levy.*

It is nocturnal, flying usually close to the ground at dusk, when it creates the droning sound characteristic of its activity. During large flights the beetles may be seen skimming over pasture. Later in the evening they settle upon turnip and rape crops and other vegetation and commence to feed, and it is thus during the night that young crops are destroyed.

On the approach of daylight the beetles cease feeding and seek shelter among the denser foliage of plants, or burrow into the ground whether covered or not by pasture. Numbers of dead beetles are often turned up when cultivated land is ploughed after large flights. In the case of roughly cultivated or stony ground the clods or other objects strewing the surface act as shelter during the day. The insect is not so active on bright moonlight nights or during windy weather, but is most lively during dull, mild, and calm evenings.

The female beetles entering the ground do so not only to shelter but also to lay the eggs. These are spherical, glistening-white, and about the size of a pin's head. Though usually laid in ground well stocked with roots, such as pasture, the eggs are not infrequently placed in the comparatively bare ground carrying a turnip or rape crop, with the result that the grass-grubs (Fig. 4) on hatching con centrate upon and devour the tender roots, a considerable check to the developing crop taking place. In the case of turnips particularly, the bulb itself is frequently attacked (Fig. 6), and although many of the attacked plants are noticeably unhealthy the greater proportion as a rule are able to recover by throwing out new roots. This type of damage is prevalent in young crops from December to March. A characteristic feature of grass-grub infestation is the pulverization of the surface-soil, which becomes quite spongy in extreme cases. On the approach of winter the grass-grubs cease feeding and burrow downwards, each constructing an earthen cocoon in which to hibernate. Activity recommences at the surface during August, when the grubs become fully grown. During September a great number, and in October practically all, have again descended and constructed cocoons for the second time. In these cocoons pupation (Fig. 5) takes place, and the van of the main November and December flights of beetles is on the wing by the end of October.

FIG. 6. ROOTS OF YOUNG TURNIPS ATTACKED BY GRASS-GRUB.

[Photo by H. Drake.

CONTROL.

The key to control should be one of avoidance. As it is not practicable to stop the flight of beetles, since they are widely distributed throughout the country and their grubs breed in ground stocked with the roots of grass—both native and sown—and of many other natural and cultivated plants, the process of control lies in regulation of the sowings of turnip and rape so that as few crops as practicable will be in the seed-leaf stage during the beetle flights. That is, in order to avoid damage the crops should not be sown till after this period, or should be sown sufficiently early before the flights to be so far developed in the second leaf as to be able to withstand attack. Since the beetle's most destructive period is during November and the first three weeks of December, crops sown in October are sufficiently advanced to be free from serious injury later. Sowings made during November and the first half of December are likely to be most seriously damaged and often destroyed. From the last week in December onwards crops can be started with safety, though minor attacks occur by late-flying beetles. Owing to the absence of crops on bare ground the beetles will not be attracted thereto except to a limited extent for sheltering purposes. In consequence, such ground being free or practically free of eggs, the chances of root-injury by grubs to subsequent crops will be proportionately lessened. Where early crops have been sown in October, prior to beetle-flight, there will, of course, be a considerable amount of egg-laying in such occupied land, but the crop will be at that period both far enough advanced in leaf and root development to withstand leaf attack by the beetle, and to a great extent root-attack by the grubs shortly after.

Though the November–December period during which crops are likely to be seriously damaged holds good throughout New Zealand,

there are slight variations. For example, in certain parts of Canterbury toward the foothills fly activity does not generally become seriously apparent until the last week in November, and continues to the third week of December; while along the coastal districts from North Canterbury to Otago extensive damage is wrought from the beginning of November till the first fortnight of December. In Southland, again, owing to the comparatively late beetle emergence, the crops as a whole are well advanced in the second leaf before the attack commences. In the North Island the November and early December period holds throughout with but little variation; in Taranaki, for example, the 1923 flight occurred throughout November, and was practically over by 12th December.

Naturally one of the greatest aids to successful crop-development in the presence of insect-depredations is the establishment of vigorous crops, and one of the serious and too-common hindrances to such is poor cultivation. Roughly cultivated land not only affords attractive and easy shelter for the beetles, but also retards the growth of crops grown therein. Under such conditions crops sown even early enough before beetle-flight may not develop sufficiently in leaf to withstand assault, and certainly are very likely to suffer from attack by the grubs owing to tardy development of the root-system. Late winter and early spring cultivation of land has a beneficial and direct effect to a certain extent on the control of the grubs, since the nearly mature grubs are exposed on the surface and devoured by birds, which almost invariably follow the plough. Mr. J. G. McKay, of the Ashburton Experimental Farm, stated that when ploughing to a depth of 5 in. during August enormous numbers of the beetle grubs were turned up and devoured by swarms of sparrows. In this respect starlings are also helpful, and will dig up the grubs from infested ground when the insects are active near the surface. However, though great numbers of grubs must thus be destroyed and as many adult beetles prevented from developing, the general effect on the fly situation is but limited, since beetles sufficient to carry on destruction develop in the extreme areas of neighbouring uncultivated land. A common practice in Canterbury is to light fires at night in order to attract and destroy the beetles, but such a method gives but an unsatisfactory control at best.

The grass-grub is apparently comparatively free from insect enemies, though predaceous subterranean larvæ of various insects no doubt prey upon it. One type of such was found to do so, this being the larvæ of two species of native robber-flies. These larvæ (Fig 7) are more or less maggot-like in colour and shape, but much longer, and have delicate white hairs projecting from the rather large terminal segment. When fully grown they transform in the ground to pupæ (Fig. 8), and the adult flies finally emerge therefrom and leave the ground. The flies are two-winged insects, and are known as "robber-flies" from their habit of capturing other insects and sucking them dry. They are long and narrow bodied; the larger (*Itamus varius*) measures about $\frac{4}{5}$ in. long and is black (Fig. 9); the smaller (*Sarapogon antipodus*) is about $\frac{3}{5}$ in. long and is reddish with black and yellow markings (Fig. 10). The larger captures such insects as the house-fly, stable-fly, and even the honey-bee.

FIG. 7. LARVA OF THE SMALLER ROBBER-FLY (SARAPOGON ANTIPODUS), AN ENEMY OF THE GRASS-GRUB. × 2½.

FIG. 8. PUPA OF S. ANTIPODUS. × 2½.

FIG. 9. THE LARGER ROBBER-FLY (ITAMUS VARIUS). × 2.

FIG. 10. THE SMALLER ROBBER-FLY (SARAPOGON ANTIPODUS). × 2.

[*Photos by H. Drake.*

THE CUTWORM.

Reference has already been made to seedling turnips being injured in the characteristic "fly" manner along the headlands of fields. Unlike the beetle-attack, such injury is not restricted to the November–December period, but appears among the earliest-sown crops. It is the work of the "cutworm," the blackish caterpillar of a moth (Fig. 11).* A feature of this phase is that such damage is most prevalent in the

* The commonest species of cutworm found attacking turnips is *Agrotis ypsilon*, but another species is *Ariathisa coma*. The former was abundant in Taranaki, while the latter was reared from material brought from Otago and Southland.

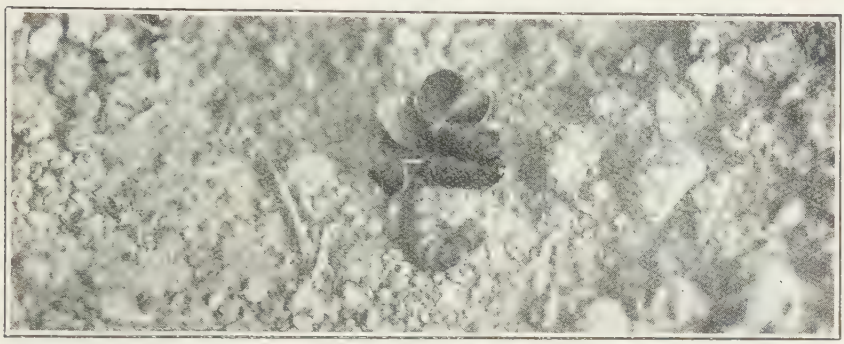


FIG. 11. CUTWORM (×) AT WORK ON YOUNG TURNIP-PLANT.
Photo taken by flashlight at 11 p.m.
[*Photo by F. E. Ward.*

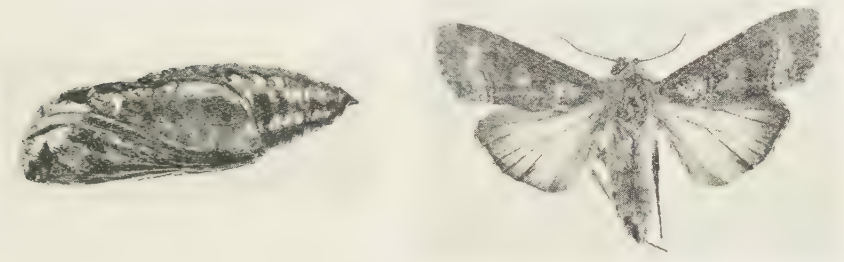


FIG. 12. PUPA OF CUTWORM. × 2.

FIG. 13. PARENT MOTH OF CUTWORN (AGROTIS YPSILON). SLIGHTLY ENLARGED.
[*Photos by H. Drake.*

vicinity of hedgerows and coarse grass. This is to be expected, since it is in such places that the moths shelter and lay their eggs, and the caterpillars feeding upon the grasses migrate on to a crop as soon as it appears above ground. These caterpillars are nocturnal, and during the day are usually found just beneath the surface of the ground curled up at the roots of the plants attacked the night before; as a rule there is a single caterpillar to one plant. When in the seedling stage turnips, and practically any other crop just above ground, are completely devoured, the stems being nipped off close to the ground. The injury, though most apparent in early growth, is not confined to it, but may continue throughout the life of the plant. At later stages of growth a leaf-petiole is eaten through, so that the leaf falls to the ground and is there devoured. The cutworm is a ground feeder, and very often drags a leaf or a portion of it underground into its resting-place. Damage to turnips when well formed is not apparent on the foliage, but is very marked on the root itself where it stands above ground, in many cases the cutworm having "ring-barked" the root

FIG. 14 (LEFT). TACHINA-FLY (PHOROCERA MARGINATA). × 4.
FIG. 15 (CENTRE). DEAD CUTWORM, SHOWING EXIT HOLE OF PARASITE GRUB. × 4.
FIG. 16 (RIGHT). PUPARIUM OF PARASITE (PHOROCERA MARGINATA). × 4.
[*Photos by H. Drake.*

just above the soil-surface. It is the spring brood of cutworms that damage the foliage of young turnips, but the "ring-barking" is the work of a second or third generation. The caterpillars transform to pupæ in the ground (Fig. 12), and from these the moths ultimately emerge (Fig. 13).

The depredations of cutworms are difficult to control owing to the prevalence of hedges with their associated growth of coarse grass. If it were practicable to keep the dense growth of grass in such places within bounds there would be a marked improvement, as the cutworms would have to find quarters elsewhere. But autumn cultivation should help to reduce the numbers of moths, since the subterranean pupæ would be destroyed in considerable numbers.

These cutworms are parasitized by the grub of a tachina-fly (*Phorocera marginata*). This is a two-winged insect (Fig. 14) and resembles a bluebottle in general appearance and size, but the body is much more bristly. The egg of this fly is apparently laid on the caterpillar, and the grub on hatching bores into the body of its victim. When the parasite is full-fed it kills the cutworm, cuts its way out of the latter (Fig. 15), and transforms to a blackish barrel-shaped pupa in the ground (Fig. 16). The adult fly emerges by pushing off the end of the pupa-case.

Starlings are great hunters of cutworms, and it is no uncommon sight to see these birds at work fossicking under the soil about the roots of damaged plants, in practically every case a caterpillar being found and destroyed. A notable feature is that the birds almost invariably confine their attention to plants showing signs of cutworm injury.

OTHER CAUSES OF TURNIP-INJURY.

In some cases rabbits will attack young turnip-crops, but their depredations, though certainly sensibly extensive at times in certain localities, are as a whole of minor importance compared with those of the fly.

The diamond-back moth (*Plutella cruciferarum*) and the cabbage-aphis (*Brevicoryne brassicae*) must rank as two of the most serious pests of turnips, rape, and other cruciferous crops. A considerable amount of investigation has been carried out with regard to these insects, and they will form the subject of future work.

It may be mentioned here that the urgent need of investigating the problem of the "turnip-fly" was brought up by farmers at the Ashburton Farm School last year.

CIDER-MAKING.

PRACTICE FOR NEW ZEALAND CONDITIONS.

(Concluded.)

J. C. WOODFIN, Vine and Wine Instructor.

SPECIAL CIDERS AND THEIR MAKING.

Dry Cider.

THE simplest cider to make is that known as dry cider. This is allowed to continue fermenting until the fermentation ceases naturally. The dry or hard ciders are, as a rule, not appreciated by the general public, though preferred in cider-making districts. A little sugar or honey added when partaking of it renders the cider more agreeable to those consumers who do not care for it dry. It is preferable to bottle the cider before it becomes absolutely dry. It is not possible to give a fixed degree at which to bottle, as the degree will vary according to the original sugar content and consequent alcohol produced. Alcohol being lighter than water, more or less of it in proportion to the water content of the cider will affect the hydrometer accordingly.

Sparkling Cider.

Sparkling cider requires either from six weeks at a temperature of 55° F. or two months or more maturing in the bottle at a temperature of 40° F. to develop the effervescence, and it is advisable to leave it at least another month in the cellar to mature. No exact period can be given for the maturing of cider: this varies with its composition and the conditions under which it is fermented and matured. Generally speaking, cider is sufficiently matured for consumption in about twelve months from the time of extracting the juice, though it will improve considerably if kept for a longer period under suitable conditions.

When thoroughly matured the cider should be clear and bright, sparkling in the glass, have a pleasant flavour and bouquet, be

invigorating but not intoxicating in effect, and leave an agreeable after-taste on the palate.

The effervescence produced by secondary fermentation in the bottle will continue for a long time in the glass after the cider is poured out. This, added to its superior flavour and bouquet, distinguishes it from the sparkling cider produced by pasteurization and artificial carbonization. Large quantities of artificially carbonated cider are produced in England and Germany, and the best of it makes an excellent beverage. When made on a large scale it can be produced quicker and at less cost than the sparkling cider in which the effervescence is produced by secondary fermentation.

Champagne Cider.

The production of champagne cider, which when well made is very similar to real champagne, is rather costly, as it necessitates more handling and considerable material. It can be made by exactly the same process as for champagne wine, utilizing matured cider from the previous year and adding a sugared liqueur, clarifying-medium, and wine-yeast. A simpler method is to bottle the cider in the same year as it is made (as in the making of sparkling cider), at 2·5° Baumé, using cider which registered at least 8° B. when in the state of unfermented juice, and containing about 0·3 per cent. of malic acid at the time of bottling.

Temporary corks are placed in bottles and held in place with special clamps. The bottles are then laid on their side in the cellar to develop the necessary gas by secondary fermentation. This usually requires from six weeks to two months. The bottles are then shaken and placed neck downwards in special stands, where they are given a sharp turn every day until all the sediment falls on the cork. The exact moment for placing the bottles on the stand can be judged by an experienced maker from the state of the line of deposit on the bottom side of the bottle. When the sediment is well settled on the cork the bottles are taken from the stand, holding the neck down, the cork smartly withdrawn, and the neck brought quickly into an upright position, the sediment being thrown out by the escaping gas into a barrel prepared for the purpose. Or the sediment is frozen on to the corks by placing the necks of the bottles in a freezing liquid, and the frozen sediment withdrawn with the cork. In both these operations there is a slight loss of cider, which is replaced by a liqueur prepared by mixing some cider with certain proportions of sugar, alcohol, and citric acid. The bottles are then permanently corked and wired.

Light Cider.

Light ciders for home use can be made from the apple-pomace which has already been pressed once, by breaking up the pomace and soaking it with as much warm water as the juice which was extracted. The pomace is placed in a barrel with one end taken out, and the loose end placed on the surface to exclude the air; the pomace is left to soak for about twelve hours, then repressed, and the juice fermented alone or added to the pure juice of the first pressing. The saccharine contents of the second juice will naturally vary with the greater or lesser pressure the pomace was subjected to in the first place.

To facilitate the rapid fermentation of light ciders for home consumption the fermentation vessel can be placed in a warm shed, and 1½ oz. of ammonium phosphate added to each barrel of 42 gallons. The phosphate supplies extra food for the ferments, invigorates them, and assists in their rapid propagation. It is consumed in the process and leaves no disagreeable after-effect. In a couple of months' time, and after racking once or twice, the cider will be ready for consumption. Either pure or diluted juice can be treated in this manner.

In several of the cider-producing countries large quantities of cider are consumed as soon as the first or tumultuous period of the fermentation is over. It has a pleasant, sharp, fruity flavour in this state, contains 1½ to 2 per cent. of alcohol, and makes an excellent beverage in hot weather.

Apple-wine.

In the Nelson District for many years past it has been the custom to make a home-made wine from apple-juice by adding from 2 lb. to 3 lb. of sugar to each gallon of juice. This makes an excellent liqueur wine, and when well made from suitable apples is superior to many of the imported grape-wines.

An exceptionally good type of apple-wine is made by adding 2½ lb. to 3½ lb. of honey to each gallon of apple-juice. The resulting wine after maturing four or five years resembles very closely a high-class sweet sherry. The degrees Baumé of these fortified juices should read from 18 to 20 before fermentation sets in. A cool cellar is not necessary nor advisable for maturing these sweet wines; in fact, they mature better in a warm atmosphere; nor need the air be excluded so rigorously as in making cider; its oxidizing effect assists the maturing process.

BOTTLING.

A little experience under local conditions is necessary to bottle cider successfully, but as a general rule dry cider which will show a slight effervescence when the bottle is opened can be bottled at 1° B., sparkling cider at 1·5° to 2°, and for an extra fizzy or champagne effect at 2° to 3°. It is not advisable to bottle at a higher gravity than 3·5° B. Very few bottles will stand the pressure produced, and through superfluous effervescence much cider will be lost on opening them. When the cider is bottled at 1° B. the bottles can be filled to the cork and laid on their side in the cellar without wiring. For ciders which are liable to be shaken in travelling it is preferable to leave a space of about 2 in. between the cork and the liquid. Ordinary bottles may be used for ciders of a lower gravity than 2° B.; above that it is necessary to use strong beer and champagne bottles. Good wine-corks should be employed—perfect at least at one end—and these should be boiled before using. The writer has found more bottled cider spoilt in New Zealand through defective corks than from any other cause. The corks of all ciders bottled at a higher degree than 1° B. should be securely wired.

Cider should be quite clear for bottling. It will generally clear itself in cold weather, when the ferments are less active. It should be exposed to the effects of the cold as much as possible, and closely watched for the propitious moment. To check fermentation and clear the cider

it is sometimes necessary to rack it into a barrel containing sulphurous fumes produced by burning a piece of sulphur wick or by the addition of sulphurous acid in the form of metabisulphite at the rate of 2 oz. per 100 gallons of cider. If it does not then clear, and the cause is an excess of albuminous matters suspended in the liquid, an addition of tannic acid (1 oz. to a 42-gallon barrel), dissolved first in hot water or cider and then well mixed into the bulk of the cider, can be tried, followed by another racking after a few days into a sulphured barrel, if necessary.

When a filter is available the cider should be bottled straight from the filter. If the cider is bottled in a cloudy condition a greater quantity of sediment will be formed. Cider which continues fermenting in the bottle always forms a small deposit of sediment, and to minimize the effect of this it is advisable to stand the bottles in an upright position the day before they are required for consumption. An excess of gas leaving the cider when the bottle is opened is likely to raise this sediment, and for this reason it is preferable to bottle the cider at 1·5° to 2° B. This should give sufficient effervescence without raising any of the sediment.

PRESERVATION IN BULK.

Cider is undoubtedly best preserved in bottles, and the lighter the cider the greater the risk of keeping it in the wood. However, dry or slightly effervescent ciders (a little life should be kept in the cider if possible) can be kept satisfactorily for some time in barrels that have been varnished or treated with paraffin-wax so as to render them air and gas tight. The cider is filled in up to the bung, which should be tight-fitting and without sacking wrapped round it, and a little melted tallow or paraffin-wax run round it. Bungs 4 in. or 5 in. in length dipped in tallow or wax should be used in the cellar. They are much easier to withdraw from the barrel than shorter bungs.

When a barrel of dry cider is tapped for gradual consumption it is advisable to protect the surface of the cider from the air by covering it with a thin layer of neutral oil; vaseline oil is probably the best procurable for the purpose.

To prevent cider in untreated barrels becoming quite dry, when it is intended to bottle it at a later date, and to assure the generation of sufficient gas to protect the surface of the cider when the barrel is partly empty, an addition of sugar at the rate of 8 oz. per month and per barrel of 42 gallons will suffice to keep up the supply of gas.

In commercial cider-making establishments, where large wooden or glass-lined cement vats are used for maturing and storage purposes, carbon-dioxide gas is introduced through a system of pipes and taps from cylinders charged under pressure with the gas, to fill up the partly empty vats and keep the cider from going sour.

PERRY.

Perry is made from pears in the same manner as cider from apples. It is often employed in the manufacture of imitation champagne. When pears are available they can be mixed in a small proportion with apples for making cider, or a small proportion of apples can be employed

in the manufacture of perry. About 10 per cent. of either would not materially alter the nature of the cider or of the perry. Quinces are also recommended for giving an extra flavour to cider. As the juice is rather difficult to extract, it is advisable to let the quince-pomace macerate after grinding, protected from the air, for twelve to twenty-four hours before pressing; or the quinces can be boiled and then pressed, and the juice added to the apple-juice.

CARE OF CELLAR AND PLANT.

The most scrupulous cleanliness should be exercised in regard to the cellar and plant—everything, in fact, that comes in contact with or near the cider. This is most important. Cider is very subject to deterioration through taking up bad odours and flavours from its surroundings, and extremely susceptible to invasion by vinegar bacteria. The press-house and cellar should be thoroughly white-washed, and the floors concreted—more especially that of the press-house—and well drained. A good water-supply is essential for hosing and scrubbing down the mill and press every day, and for cleaning barrels, washing press-cloths, &c. Press-cloths should be washed daily in water to which a little washing-soda has been added to neutralize the acidity, and then rinsed in pure water.

Barrels and vats should be kept quite dry and sweet when not in use. As the barrels are emptied they should be well rinsed out with clean water and allowed to drain, and, when dry, filled with sulphur-fumes by burning a piece of sulphur wick in them and then bunging them tightly. This treatment, which should be renewed about every three months, will keep the barrels free from mould.

When examining a barrel before use, to ascertain if it is in a suitable condition to store cider in, take out the bung and give the barrel a sharp rap with a stick or piece of wood; then place the nose near the bung and inhale the air from the barrel. If the slightest vinegary, mouldy, or other foreign odour is perceived, pour a solution of hot water and soda (1 lb. to the gallon) into the barrel, bung it down, and roll the barrel about for ten minutes, then rinse with clean water. Now prepare a 10-per-cent. solution of bisulphide of lime and water, pour it into the barrel, and roll the latter again for fifteen minutes. Rinse again, and fill the barrel with clean water, and let it remain therein for a day or two. This treatment will be found efficacious in eradicating slight acetic or mouldy taints. Barrels or vats having more than a very slight acetic taint before treatment should not be used for storing cider.

CONCLUSION.

In conclusion, it will be gathered from the perusal of this brief account that good cider is not difficult to produce, provided that good, sound, ripe apples are used, that the utmost cleanliness is exercised in the process, and that the cider is protected from all unnecessary contact with the air.

Noxious Weeds.—The Bruce County Council has made a special order that Canadian thistle shall be deemed not to be a noxious weed within that county. The Mount Albert Borough has declared fennel a noxious weed.

IRRIGATION AND ITS PRACTICE.

(Continued.)

II. SOME PRINCIPLES AND DEFINITIONS.

R. B. TENNENT, N.D.D., Instructor in Agriculture, Dunedin, and J. R. MARKS, A.M.Inst.C.E., M.N.Z.Soc.C.E., Resident Engineer, Public Works Department, Alexandra.

PHYSICAL NATURE OF THE SOIL.

THE adaptation of a soil to irrigation depends to a large extent upon its physical nature, and it is therefore desirable that the irrigation farmer should have a clear conception of the characteristics of the soil with which he is dealing, for to a large measure his success or failure will be controlled by its texture and formation. No apology is therefore needed in introducing some elementary facts of soil physics, and every intelligent irrigator will appreciate the direct relationship of this science to the practice of irrigation.

In speaking of the soil we refer to the layer of unconsolidated material, derived from rocks by the process of weathering, which covers the land surface of the earth almost everywhere. This material varies in composition according to the rock from which it has been derived, and as the bulk of soil in Central Otago is derived from mica-schist it is classified as a mica-schist soil. The weathering of rocks may be due to two agencies, one being physical and the other chemical. The physical weathering of rock or disintegration may be caused by (1) heat and cold, (2) freezing and thawing, (3) the action of glaciers, (4) erosion of streams, waves, and wind, and (5) the action of plants and animals. Chemical weathering might be looked upon as decomposition whereby the rocks are affected by acids such as carbonic and sulphuric acid, oxidation and deoxidation, the solvent action of weather, &c.

For convenience the soil may be divided into two strata, the top soil and subsoil. The top or surface soil refers usually to that portion cultivated with the plough, and as organic matter and fertilizers are incorporated in this stratum the majority of our crops have their roots there. This stratum of the soil is the more fertile, but is usually deficient in lime, and it is here that the most favourable conditions for bacterial growth and activity are to be found.

The subsoil usually extends to a considerable depth, and is of great importance to the irrigator because drainage, water-movement, root-penetration, and resistance to drought largely depend upon its character. The surface soils of Central Otago do not differ greatly from the subsoil, because the fine particles are not moved downwards by percolating water. Further, certain soluble substances are present which flocculate the colloidal clay and so prevent its deposition. An arid subsoil such as obtains in Central Otago does not possess the raw and unproductive nature common, for example, to the soils of Southland. Hence very deep ploughing may be carried out without detriment immediately preceding the sowing of the crop—in fact, it is of the greatest benefit, because it allows of deeper root-penetration and

greater moisture-retention. In the process of levelling preparatory to irrigating the soil may sometimes be removed to a depth of several feet without injurious effect on the subsequent crop. In humid districts the farmer must be careful not to turn up too much unweathered material just preceding the time of sowing, and if deep ploughing is done sufficient time should be given for the soil to weather before the crop is sown.

Of the many soil-constituents the most valuable is undoubtedly the organic material derived from plants and animals that have lived in and on the soil. This organic matter varies considerably even in the same locality. Table 5 gives a summary of analyses showing the percentage of organic matter present in the soils of Central Otago, North Otago, South Otago, and the Southland Plains respectively.

Table 5.

District.	Number of Analyses.	Percentage of Organic Matter.
Central Otago	29	5·28
North Otago	7	10·39
South Otago	9	7·92
Southland Plains	12	10·89

From this it will be seen that the organic content of the soils of Central Otago is low.

To the irrigator organic matter has a special significance quite apart from its value as a source of plant-food. A soil high in organic matter not only retains a good physical condition, but upon its presence or absence depends to a large extent its water-holding capacity. Thus soils with a high organic content will absorb and retain more moisture than soils with a low organic content. There is no better method of increasing the water-holding capacity of soils than by adding organic matter, and the simplest manner by which this can be done is in growing a crop of clover and ploughing it under. This practice will most assuredly have to be carried out on many farms of Central Otago, as in the majority of cases the soils there show a lack of sufficient humus-forming material. A soil with a few tons per acre of fresh green easily-decaying matter, such as lupins or clover, ploughed into it will act like a sponge, and when mixed with the mineral portion of the soil will give higher porosity and greater moisture-holding capacity. Its presence retards capillary movement in the soil and induces a better mulch, thus helping to retain moisture by reducing evaporation. When organic matter is added to sand its capacity for holding moisture is considerably increased, as Table 6 exemplifies.

Table 6.—Effect of Organic Matter on the Retention of Moisture in Sand.

Soil Material.	Grams of Water retained.	Percentage of Increase.
Coarse sand	13·3	..
Coarse sand with 5 per cent. of peat ..	18·6	40·0
Coarse sand with 10 per cent. of peat ..	24·7	85·7
Coarse sand with 20 per cent. of peat ..	40·0	200·7
Peat	184·0	1283·4

The Central Otago settler, therefore, realizing the need for building up his soil in organic matter, should certainly make a practice of growing special crops for such a purpose, and there is no doubt that the extra cost of labour which this practice involves will be amply repaid by increased returns.

WATER AND THE SOIL.

Soil-water: When it is remembered that plant-growth cannot take place without water, and that plants in themselves consist of from 60 to 90 per cent. of water, it will be realized that the importance of soil-water warrants a brief discussion. The large percentage of water contained in plants by no means represents the amount required by them in the process of growth from the seedling stage until maturity is reached, for a continuous stream is passing in through the roots, and is finally transpired through the minute openings or stomata of the leaves. As the amount of water required to produce 1 lb. of dry matter is from 300 lb. to 800 lb. the soil must contain a sufficient amount of moisture, and must also be in such a physical condition that this supply can readily be delivered to the plants. If a sufficiency of water is not forthcoming the plant will gradually wilt and die before full maturity has been reached.

Water exists in the soil in three conditions—hygroscopic, capillary, and gravitational. The water under each of these conditions is of the same chemical composition, differing only in the force holding or moving it.

Hygroscopic moisture: At ordinary temperatures a very thin film of moisture adheres to the soil-particles, and this moisture cannot be driven off unless by the application of great heat. This is called "hygroscopic moisture" and cannot be used by the plant. From twenty-nine analyses made of the soils of Central Otago the hygroscopic moisture was estimated as being 3·21 per cent. As the plant is unable to make use of this moisture it might be thought that its wilting-point would be reached when the water content was 3·21 per cent., but such is not the case. Determinations have been made of the wilting-point of plants in soils with the above-mentioned percentage of hygroscopic moisture, and it appears that this point is reached in such soils when the moisture content is in the vicinity of 4·5 per cent.

Capillary water: When water is applied to the ground, either in the form of rain or by irrigation, a portion runs off the surface, leaving the remainder to soak into the soil. A certain proportion of this water, in the course of its passage through the earth, is retained on the surface of the soil-particles and in the interstices, and does not drain away. This is termed "film" or "capillary" water. Capillary water is the form used by plants, but even under the driest conditions they are unable to use the total amount of film-water present in the soil. This water does not soak away into the lower levels of the soil, but is capable of moving sideways and upwards to the surface by capillary attraction, creeping from film to film and through the minute spaces occurring in the soil until it finally reaches the surface. There it is evaporated by the sun and wind, the water from the lower strata coming up to take its place.

To prevent loss of this water should be the aim of every irrigator, and the manner in which this is most easily accomplished is by periodically stirring the surface of the soil with cultivators and so forming a soil-mulch. By stirring up the surface after each irrigation and after each fall of rain capillary movement to the surface is retarded and little loss of moisture occurs through evaporation. Some soils such as sand, peat, &c., are self-mulching, but this is not the case with the soils of Central Otago. There the soil, after irrigation, settles into a hard cement-like form, readily cracking (Fig. 12), and in this condition evaporation takes place very rapidly. With such conditions obtaining it is of prime importance that soil-mulches

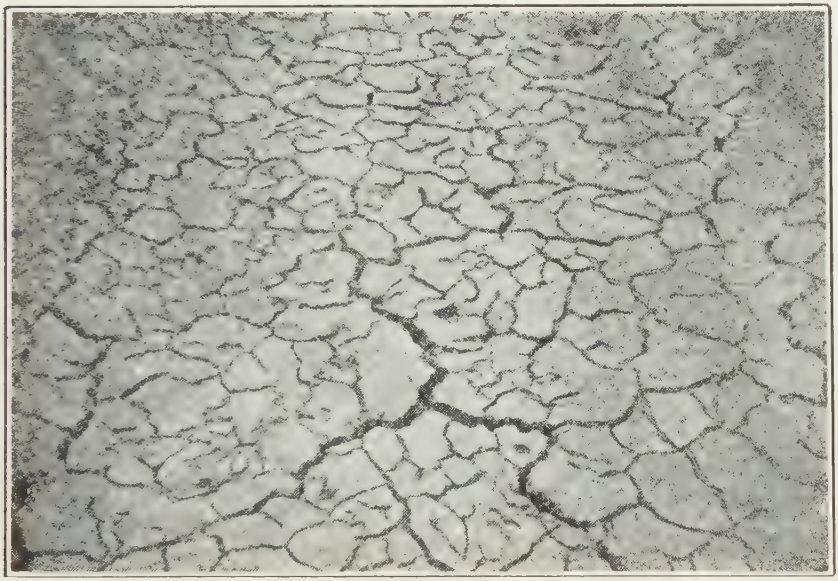


FIG. 12. LAND IN BAD PHYSICAL STATE AS RESULT OF DRY CONDITIONS.

The soil is cracked to some depth, and the moisture is fast leaving the ground.

[*After Van Slyke.*

should be formed when occasion demands it, and the successful irrigator desiring to make the most economic use of his water, and incidentally with a view to lessening the number of irrigations required, will assuredly make a practice of cultivating his land, whenever practicable, after every application of water or fall of rain.

This is a feature of irrigation which every settler should be acquainted with. The loss of moisture by evaporation following an irrigation is very great, particularly when the crop is in its early stages with little or no growth to shade the ground. At Galloway Experimental Area it was found that where the ground had not received cultivation till eight days after irrigation the water lost by evaporation was in the vicinity of 2 in., or 227 tons per acre. On adjacent

ground where surface-cultivation had been carried out after irrigation the loss amounted in eight days to $\frac{1}{2}$ in., or approximately 57 tons per acre, being a reduction of 75 per cent. Fig. 13 (adapted from Fortier) shows how effectively cultivation after irrigation retains moisture in the soil. In this case, had the cultivation begun as early as the second day instead of the fifth day after irrigation the loss of moisture would have been materially less than is shown. This is a typical instance of the value of cultivation after irrigation, and the necessity for carrying out this practice whenever possible cannot be overstressed.

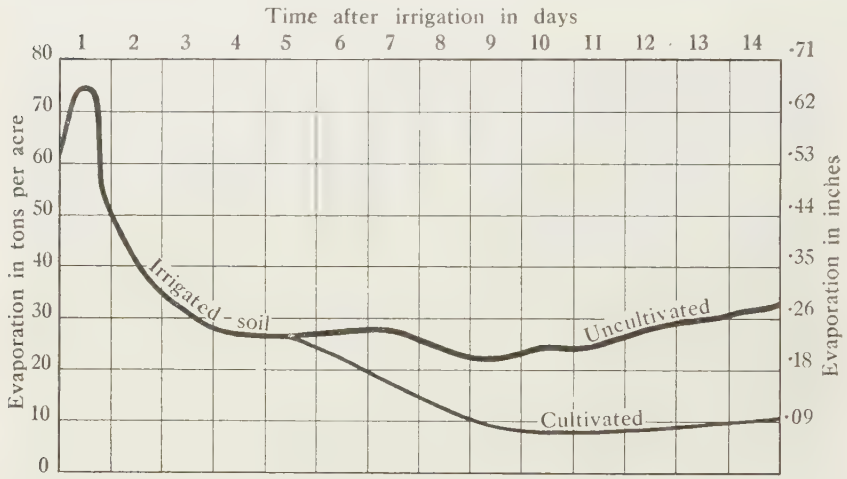


FIG. 13. GRAPH SHOWING SAVING OF WATER RESULTING FROM EARTH MULCH FORMED BY CULTIVATION.

Gravitational water: Gravitational or free moisture saturates the soil, filling the spaces existing between the soil-particles. It moves downwards into the subsoil under the influence of gravity until it reaches a fixed level where the pore-spaces are already full of water. The level varies considerably in different locations; in some it may be many feet, in others within a few inches of the surface, while in some cases it is at the surface. This level of free water is termed the "water-table." The water-table is the level at which water stands in wells. This water can be utilized by the plant when it is below the layer of root-growth but sufficiently near to the surface to be drawn up by capillary attraction to the upper layers of the soil. When so near the surface as to saturate any portion of the soil penetrated by roots of crops it may be regarded as unavailable, injuriously affecting growth in most crops in that it shuts off the needed supply of air, making the soil cold, and thus preventing the formation of nitrate nitrogen. Further, its presence promotes the formation of compounds poisonous to plants, retards the decomposition of organic matter, and produces other conditions unfavourable to crop-growth.

In Central Otago, generally speaking, the porous nature of the subsoil does not permit of the water-table rising to a height where damage is likely to result. But, of course, there are certain localities in that district, notably portions of Ida Valley, where excessive irrigation on the slopes flanking the valley result in raising the water-table to such a height that swampy conditions result to the serious detriment of the crops growing thereon (Fig. 14). Such undesirable conditions can only be prevented from arising by a more sparing use of water in small quantities at frequent intervals, and the water-table must be lowered by a proper and adequate system of drainage.

FIG. 14. RUSHES APPEARING IN IDA VALLEY AS A RESULT OF OVERIRRIGATION.

ALKALI.

In semi-arid regions many soluble substances are formed by the decomposition of rocks, and these, generally speaking, would be washed out of the soil to a large extent if the rainfall were sufficient. As it is they accumulate in arid soils and are sometimes brought to the surface, where they are deposited in such accumulations as to seriously inhibit the growth of normal plant-life. These injurious salts are chiefly the chlorides, carbonates, and sulphates of sodium, or may on occasion prove to be the chlorides or sulphates of magnesium or potassium and other salts.

While not wishing to alarm settlers in Central Otago of the future probability of these alkalis accumulating on their farms, and so rendering the soil thereon unproductive, it must be stressed that the effect of using too much water has a decided tendency to accelerate an increase in the deposition of these salts. It can readily be understood that when large quantities of water are applied to the ground a considerable proportion of these salts are turned into solution. Excessive evaporation follows excessive watering, and the dissolved

salts are by capillarity brought to the surface of the soil, where they are deposited. In Ida Valley the writers have observed small patches of white alkali which no doubt are the direct result of overirrigation and insufficient drainage.

In certain other countries the accumulation of alkali has caused a considerable amount of anxiety, and every precaution is being taken to prevent its occurrence. It is quite probable that the decay of ancient civilizations which depended primarily upon irrigation for their existence was to no inconsiderable degree due to the slow accumulation of alkali on their agricultural lands. A rational use of water is therefore necessary, and a realization that the practice of drainage goes hand in hand with irrigation is essential. With our present knowledge of soil physics and agricultural science there is no need for a recurrence of the destruction of soil fertility by irrigation as in ancient times, provided that this science is properly applied.

DUTY OF WATER IN IRRIGATION.

Various writers have different ways of defining the term "duty of water," but for general purposes we prefer to look upon "duty of water" as being the total amount of irrigation water which must be applied to the land during the whole irrigation period in order to bring any crops growing thereon to full maturity. Duty of water in irrigation, therefore, expresses the relation between a given quantity of water and the area which it serves. The duty of water is said to be a high or a low one according as a given quantity successfully irrigates a large or a small area. From an irrigation point of view there is no problem of such great importance as that dealing with the volume of water required in the production of payable crops, when such water is applied in the most advantageous and economical method. Naturally this aspect of the question is extremely complex, and there are in New Zealand no definite data upon which to dogmatize, this branch with us being merely in its initial stages of investigation. In due course it is hoped to work out definite data in regard to the water-requirements of the various crops on the Galloway Experimental Area, which has been established for such purposes, but for the present use must be made of information obtainable from other sources.

The greatest service is rendered by a given quantity of water when applied to the soil, either in the form of rain or by irrigation, where every drop of such water is absorbed by the roots of the plants growing on the ground, thus leaving none to be lost by percolation or by evaporation from the surface. If it were practicable to ensure that all the water contained in the soil was lost therefrom only by transpiration through the stomata of the leaves of the crop growing upon that soil, then a very limited rainfall and a small irrigation would suffice. From this it will be appreciated that the duty of water in crop-production is based on the necessary losses of moisture in the soil, whether by transpiration through the leaves and stems of the plants, by capillarity and consequent evaporation, or by surface and under drainage. The aim of every irrigator, therefore, must be the limiting of water losses from such sources as just enumerated, and the more successful he is in this respect then to an equal degree will the duty of water be improved.

In Central Otago, where irrigation is necessary to bring crops to full maturity, the loss of water by drainage and surface evaporation can be reduced to a minimum by a rational method of water application at suitable intervals, and by proper cultivation to conserve moisture in the soil, the chief loss which occurs being that which is transpired through the plant itself. King, in his work "Irrigation and Drainage," gives data of the minimum number of acre-inches of water which may be made to produce yields of different amounts of various crops under conditions where no drainage occurs, and where surface evaporation is reduced to the absolute minimum. The results are given in the following table:—

Table 7.—Highest Probable Duty of Water for Different Yields per Acre for Various Crops.

Yield per Acre in Bushels.	Least Number of Acre-inches of Water.				
	Wheat.	Barley.	Oats.	Maize.	Potatoes.
15	4·5	3·21	2·35	2·52	..
20	6·0	4·28	3·13	3·36	..
30	9·0	6·42	4·70	5·04	0·82
40	12·0	8·56	6·27	6·72	1·10
50	15·0	10·70	7·84	8·40	1·37
60	18·0	12·84	9·40	10·08	1·65
70	..	14·98	10·98	11·75	1·92
80	..	..	12·54	13·43	2·20
100	..	..	15·68	16·77	2·75
200	..	..	..	..	5·49
300	..	..	..	..	8·24
400	..	..	..	..	10·99
Tons per acre ..	1	2	3	4	6
Clover hay* ..	4·43	8·85	13·38	17·70	26·55
Tons per acre ..	10	12	14	16	18
Maize with ears†	20·72	24·95	29·10	33·26	37·42
Maize silage ..	7·17	8·61	10·04	11·48	12·91

* 15 per cent. water. † 70 per cent. water.

This table, then, may be regarded as illustrating the minimum quantity of water which will bring the crops mentioned to full maturity, so as to produce the yields specified under conditions where losses by evaporation and drainage have been practically eliminated. In addition, it must be borne in mind that the soil at the time of seeding would possess the requisite amount of water for suitable germination-conditions, and that sufficient moisture would be retained therein at the expiry of the growing-period to prevent checking the vigorous growth of the plant. The table therefore serves to illustrate the minimum quantity of water necessary for the yields given; the total loss which occurs in bringing the water to the field, either by soakage or by evaporation from the various ditches, by wrong methods of applying the water to the land, or by improper methods of cultivation after irrigation, must certainly be added to the quantities given.

From a hundred cases taken from all parts of the world King deduces during an irrigation season a mean value of 20·24 in. for the duty of water. This figure is based on actual practice and not deduced from experimental data.

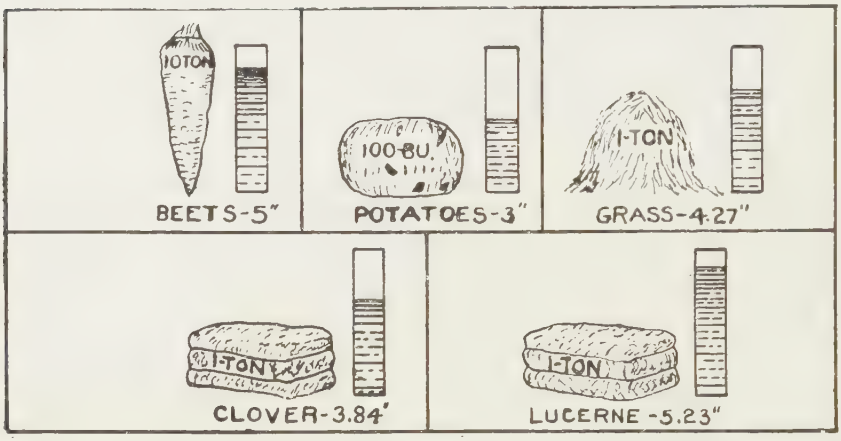


FIG. 15. DIAGRAM SHOWING WATER REQUIREMENT OF VARIOUS CROPS PER ACRE.
[*Original.*

AMOUNT OF WATER PROVIDED BY GOVERNMENT SCHEMES IN CENTRAL OTAGO.

Up to the time of writing the amount of water provided for each acre of land under the Government irrigation agreements is $\frac{1}{150}$ of a cusec flowing continuously day and night for 150 days, or its equivalent in larger quantities taken in flushes at intervals. This is equivalent to 23·76 acre-inches per season, and when it is remembered that the average rainfall is 15·18 in., two-thirds of which is available for plant-production, the allowance would appear to be a fairly liberal one, the two combined providing a total of 33·88 in. The case of Ida Valley, however, is an exception, for there the elevation of the country is higher, the irrigation season shorter, and the temperatures are not so high as experienced in the other irrigation areas, therefore the evaporation from the soil being less. The water allowed for Ida Valley is $\frac{1}{200}$ of a cusec, instead of $\frac{1}{150}$, this being equivalent to 17·82 in.

WATER RENTALS.

So far the principle adopted in regard to water rentals has been based upon providing a reasonable rate of interest and sinking fund on the capital cost of constructing the scheme. In the case of the Ida Valley scheme the charge for water is 10s. per acre per annum, but with the more recent schemes—namely, Manuherikia, Galloway, and Olrig Terrace—the charge is 16s. per acre. In the case of the Ardgour scheme the charge is 15s. per acre. These water charges, when compared with those obtaining in other countries, must be regarded as quite reasonable. For instance, the average water charges in the Yakima Valley,

State of Washington, U.S.A., work out at 15s. 3d. per acre per annum, while as high as 24s. per acre is charged in that valley. In Southern California the water charges are generally higher, in some cases the rate of 72s. per acre-foot being charged, which would represent for a supply equivalent to that provided by the New Zealand Government a charge of 144s. per acre per annum. In Central Otago a sliding scale of water charges has been adopted to facilitate the settler in becoming properly established before the full charge comes into operation. The scale is based on a charge of 1s. per acre for the first year, and gradually increases through a period of five years to the maximum charge per acre as outlined above.

FREQUENCY OF IRRIGATIONS AND THE WATER-HOLDING CAPACITY OF SOILS.

Under the heading of "duty of water" an indication has been given of the total quantity of water required during the irrigation season for the production of crops upon the land, but in order that the quantities there referred to may be used with greatest effect it is now desirable to consider the number of irrigations into which such volumes of water may be divided. At the outset it must be recognized that in the absence of definite data pertaining to Central Otago the problem presents great difficulties, and consequently we are forced to generalize on this subject.

It is, of course, recognized that various types of soils have varying water-holding capacities; for example, a heavy clay soil will hold and retain much more moisture than one that is light and loose, and this fact is of the utmost importance to the irrigator (Fig. 16). Bearing in mind the fact that the majority of the soils utilized for irrigation in Central Otago are of a fairly light, free, open nature, it will naturally be appreciated that such soils have a limited water-holding capacity—much less than the heavy soils of, say, Southland. Consequently, once the maximum amount of water has been applied in order to saturate those light soils to their full holding-capacity, then the application of any further quantities of water must result in the loss of such water by percolation, thus reducing the effective work which that water might reasonably be expected to perform. In other words, the duty of water will be fairly uniform over all the soils of Central Otago, provided a systematic study is made by the farmer of the extent to which he can best saturate his soil in any one watering, but if over saturation is carried out then the duty of water will be considerably lowered.

To come to a concrete example, there are many farmers whose soil has a water-holding capacity of 3 in. of water, but instead of dividing their yearly 24 in. supply of water into eight irrigations of 3 in. each they probably endeavour to do the work with four irrigations of 6 in. at each irrigation, and consequently find that the water-supply is insufficient for maximum crop-production. Actually the trouble is that in each irrigation the soil has been well oversaturated by at least 3 in. of water, which is lost by percolation.

Certain conditions determine the various amounts of water which should be applied at one time to the soil. These are (1) the water-holding capacity of the soil and subsoil, (2) the depth to which the roots of the crop penetrate the soil stratum, (3) the rate at which the soil

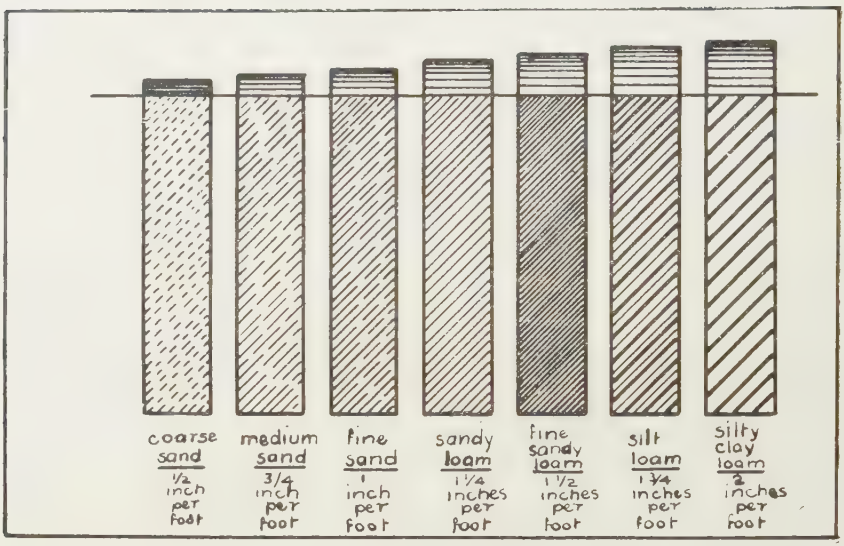


FIG. 16. DIAGRAM ILLUSTRATING USABLE WATER CAPACITY OF DIFFERENT TYPES OF SOIL.

[*Original.*

below the root zone may return water into it by capillary attraction, and (4) the degree to which the soil in the vicinity of the roots has lost its moisture.

So far as we are concerned we need only consider here the water required for plant-growth. Briefly stated, under conditions where the soil is not too dry for good growth, and where the object is to saturate the soil without causing any loss by percolation below 4 ft. to 5 ft., the amount of water required for each irrigation should range between 2·5 in. for those soils with a loose open texture and coarse grain and 4·5 in. for those having a loamy texture.

Where the moisture content of a soil is low, due to excessive drying having taken place, the amount to be applied will vary from 4 in. in the case of coarse soils to as high as 11 in. on fine soils with a high water-holding capacity. From an economic point of view, the fewer number of irrigations given to the crop the cheaper will be the cost of production, and, further, less water will be lost by surface evaporation from the ditches and from the field. For practical purposes, however, the aim of the irrigator must be to apply as much water to the crop as the soil will hold in the vicinity of the root zone, and to conserve that water by proper means of surface cultivation.

Assuming that a crop of maize may be grown in 110 days and that 12 in. of water in addition to rain is essential to bring the crop to full maturity, then, if the water-holding capacity of the soil in the vicinity of the roots is from 2 to 4 acre-inches, with proper management it should be possible on open soils to produce the crop with six irrigations, and on the more retentive soils with three irrigations, thus making an interval of from eighteen to thirty-seven days between each irrigation.

From this it will be seen that in determining the number of irrigations which a crop requires certain factors must be taken into consideration by the farmer, and it is just here that the intelligent and observant

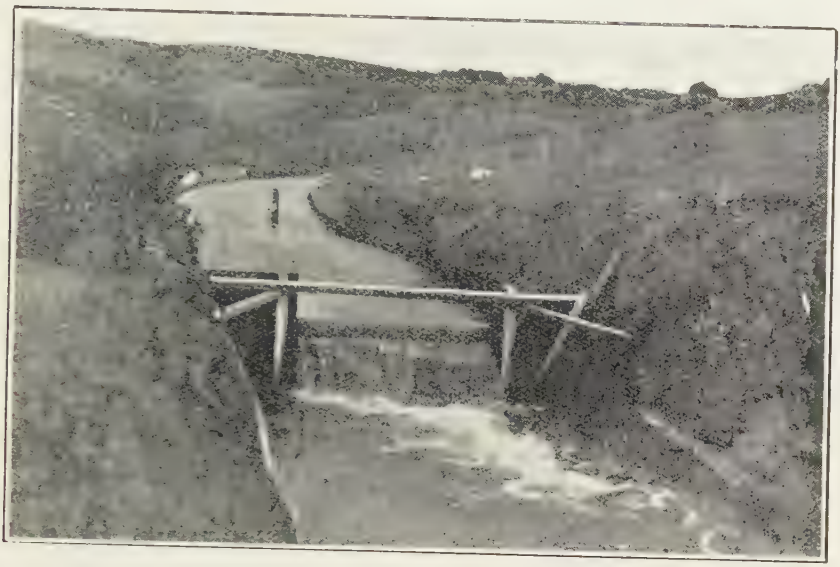


FIG. 17. MEASURING-WEIR IN A CENTRAL OTAGO WATER-RACE.

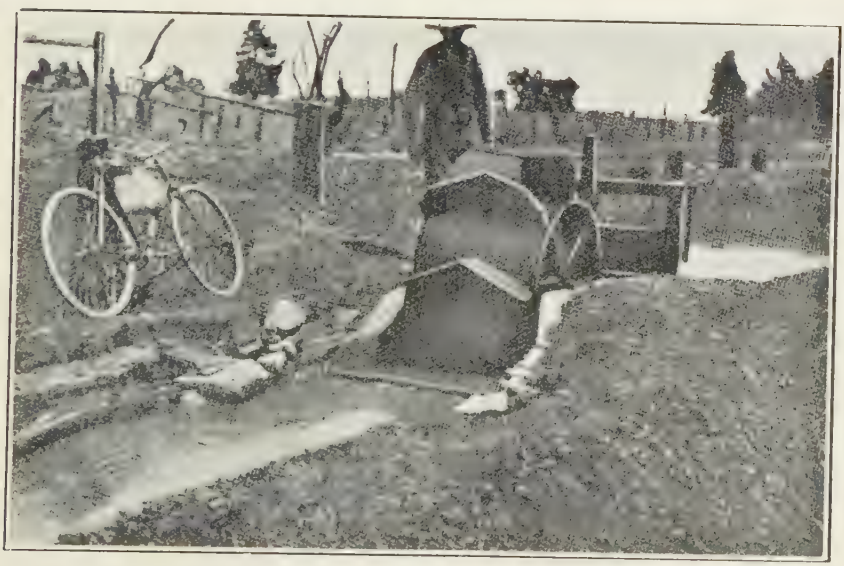


FIG. 18. WATER-METER AS USED IN AUSTRALIA.

[*After Fortier.*

irrigator will obtain the most consistent and successful results. He must first determine by observation and actual trial the amount of water which his soil can retain to a depth of about 3 ft. to 4 ft., and, having applied water to do this thoroughly, the crop can then be allowed to draw upon that moisture which is held in the soil until such a time as a deficiency of soil-moisture occurs. The period of time which will elapse between the initial stage, when the soil is fully saturated, and that when a supply is just barely sufficient to sustain the growing crop will depend on several factors, such, for example, as the class of crop, type of cultivation, and temperature; but when a deficiency of moisture occurs this fact will at once become apparent by the crop wilting. The practical irrigator, however, will never allow this wilting-point to be reached, for by examination of the soil and from previous experience he should be in a position to determine the length of time which should exist between each irrigation, and before any check in the growth of the plant takes place a second irrigation will be given.

To the practical farmer the question will immediately arise as to how the above-stated ideal may be put into practice, for having to a certain degree ascertained the water-holding capacity of his soil and the number of irrigations desirable with due regard to economy, he is at once confronted with the problem of how to irrigate his crop—say, six times in the season with 3 acre-inches of water on each occasion. To the average settler this difficulty might appear to be insurmountable when one bears in mind the common method of irrigation in Central Otago, but in the matter which now follows the writers hope to show how definite quantities of water may be rapidly and thoroughly applied to crops with due regard to the necessity of economy in all the methods advocated.

MEASUREMENT OF WATER.

It is advisable that every irrigator should appreciate the terms of measurement generally employed when computing the amount of water applied to the land. In different parts of the world various units of measurement are in vogue, but those most generally used by irrigators are the terms "cubic foot per second," "acre-foot," and "acre-inch."

Cubic foot per second: This term, usually abbreviated to "second-foot" or "cusec," represents a flow of 1 cubic foot of water per second. The term "cusec of water" is therefore in New Zealand synonymous with the miner's term "head of water," and though this latter term is in legal use in the Dominion it is at best somewhat unsatisfactory, for in the science of hydraulics the term "head" usually indicates pressure. The measurement of water is effected in several ways, such as measuring the flow over weirs or through gauge-boxes (Figs. 17 and 18).

Acre-foot: As the term indicates, an acre-foot is the volume which will cover 1 acre to a depth of 1 ft. The relation between the two measurements may be convenient in that 1 cusec flowing for twenty-four hours would cover an acre nearly 2 ft. (1·98) in depth, or one cusec for twelve hours is equivalent to 1 acre-foot.

Acre-inch: An acre-inch is one-twelfth of an acre-foot.

Where the flow of water is known in cusecs Table 8 will be of use in converting the discharge from cubic feet per second (cusecs) into acre-feet.

Table 8

Discharge, in Cusecs.	Volume in Acre-feet if the Discharge in Cusecs (Column 1) flows for				
	1 Hour.	12 Hours.	1 Day (24 hours).	1 Week.	1 Month (30 days).
	Acre-feet.	Acre-feet.	Acre-feet.	Acre-feet.	Acre-feet.
0·25	0·02	0·24	0·49	3·47	14·88
0·50	0·04	0·49	0·99	6·94	29·75
0·75	0·06	0·74	1·48	10·42	44·63
1	0·08	0·99	1·98	13·88	59·50
2	0·17	1·98	3·96	27·76	119·00
3	0·25	2·97	5·95	41·65	178·50
4	0·33	3·97	7·93	55·53	238·00
5	0·41	4·96	9·92	69·42	297·50
6	0·49	5·95	11·90	83·30	357·00
7	0·58	6·94	13·88	97·19	416·50
8	0·66	7·93	15·87	111·10	476·00
9	0·74	8·92	17·85	124·90	535·50
10	0·83	9·92	19·83	138·80	595·00

(To be continued.)

SPONTANEOUS COMBUSTION OF HAY.

AN EXPERIENCE AT MOUMAHAKI EXPERIMENTAL FARM.

J. W. DEEM, Instructor in Agriculture.

THERE is no doubt that many haystacks which are built a little on the damp side heat up and burn spontaneously. In this connection a recent experience at the Moumahaki Experimental Farm is of interest. A field of mixed clover and rye-grass was cut on 1st December last and stacked on the 5th. The day of stacking was rather dull, and the material in parts did not feel quite in condition, but as the area was only sufficient to provide a small stack it was thought safe to proceed.

The stack was kept under observation, and in about three weeks after cutting it was noticed that one end was sinking badly and that the stack was smelling and fairly warm. The condition was noted from time to time, and on 14th January, just forty days after stacking, the heat was so great that the stack was expected to go on fire at any time. A water-supply in barrels was got on hand, and a start made to cut a shaft into the stack where it appeared hottest. After the removal of a couple of feet of part hay and part ensilage charred material was reached, which burst into flames immediately it came into contact with the air, and water had to be frequently used to control the fire. This charred material, after being dampened, was loaded into a dray and carted out into a grass-paddock and dumped. The stack was then watched for several hours for fear that any lumps of the charred stuff might have been dropped among the good material and later start a fire, but so far as the stack was concerned nothing further happened.

The necessity for care, however, was forcibly brought under notice. The charred material which had been dumped—each load being put down in a separate heap in the paddock—frequently broke into flames during the first hour or two after being carted out. These fires were put out by water and further spreading of the material, the last signs of fire being noticeable about 10 p.m. on the same day. On the afternoon of the next day it blew very hard, and one of the dumped loads burst into flames and burnt to a cinder, showing that a small lump of the material had retained its heat for fully eighteen hours, going on fire only when the wind was hard enough to dry it out.

When the charred material had been removed from the stack a hole was left approximately 10 ft. long, 8 ft. deep, and 3 ft. wide, the actual seam of burning material being 10 ft. by 3 ft. by 2 ft. One end of this seam had reached within 1 ft. of the outside wall of the stack, and had it been left another day or so it must have broken through and destroyed the whole stack. Surrounding the charred material there was a quantity of ensilage, but there was evidence that this was being gradually dried and burnt. The ensilage portion of the stack was fed out to the dairy herd and eaten with relish by the cows.

Extensive experiments on spontaneous combustion of hay have been recently carried out by Messrs. J. S. Haldane and R. H. Mackgill, of the Cherwall Laboratory, Oxford. The following extract from a valuable paper by them, published in *Fuel in Science and Practice*, discusses the results of the investigation:—

Although the spontaneous firing of a haystack is, like that of a mass of broken coal or other easily oxidizable material exposed to the action of oxygen, due to an oxidation process, the process in the case of hay has peculiar features owing to the initial co-operation of living organisms in the oxidation process. The experiments have shown, however, that there is no essential difference between the process in the haystack and in a mass of coal. The rapid development of heat in a large mass of damp hay is due almost entirely to the growth and activity of bacteria, of which one species raises the temperature to about 42° C., while another species, which then begins to grow, can take the temperature to near 70° C. Oxidation, however, occurs in the damp hay at ordinary temperatures at a limited rate even when bacterial action is absent; and a perfectly sterile haystack would be capable of spontaneous firing if it were large enough and were given sufficient time, just as any sufficiently large mass of broken coal is capable of spontaneous firing.

The fact that haystacks do not spontaneously fire more frequently is in the long-run due to their being of only moderate size. With stacks below a certain size the hay can never fire, since even if there is considerable heating from bacterial activity the heat produced by purely chemical activity at the temperature to which the bacteria have been able to raise the hay is too small to balance the loss of heat from the surface.

The connection between the amount of moisture present in hay and the rate of oxidation or heat-production, whether bacterial or purely chemical, comes out quite clearly in the experiments. It seems that when hay is stacked it should contain sufficient moisture just to secure the advantages arising from bacterial fermentation, while bringing the bacterial activity to an end as soon as a comparatively small amount of water has evaporated from the warm stack. The stack should also not be so large or high that the heat produced by purely chemical oxidation at the maximum temperature produced by the bacterial action cannot readily escape to the surface. Under these conditions the stack heats to about 60° C. and then cools down owing to cessation of bacterial activity. If, however, the stack has so great a diameter and height that the comparatively small amount of heat produced by chemical oxidation cannot escape as quickly as it is liberated, the stack will go on rising in temperature till firing or smouldering occurs. With a large stack the temperature must either go on

rising or go on falling. There is no half-way course, since the rate of chemical oxidation at a constant temperature becomes less and less with lapse of time. It is evident, also, that hay that has been put into small stacks in a rather damp state, and then allowed to warm up and partially dry, will be much less apt to heat dangerously in a large stack. In this respect hay resembles coal.

At a low temperature the rate of oxidation in damp hay is much greater than in freshly powdered coal at the same temperature. Thus 100 grm. of damp hay at 40° C. absorbed 278 c.c. of oxygen per hour as compared with an initial oxidation of 43 c.c. of oxygen per hour for 100 grm. of the readily oxidizable Barnsley seam hard coal. Moreover, in the case of hay the heat produced per cubic centimetre of oxygen absorbed is presumably about double that produced in the oxidation of coal. It is thus easy to see why damp hay heats to a certain moderate temperature so much more readily than coal. When, however, the temperature rises to the point when bacteria can no longer live, the purely chemical oxidation which still persists in the hay is comparatively small, so that further heating, if it occurs at all, is very slow. This further heating can, however, only occur in very large stacks. Thus it comes about that while steaming or "sweating" of coal is a certain sign of imminent danger of firing, the steaming of a haystack is usually nothing but a sign that an advantageous amount of fermentation is occurring; and if the temperature in any part of the stack does not exceed about 70° C. (or 160° F.) firing of the stack need not be feared.

In the foregoing discussion the experimenters state that haystacks below a certain size can never fire. The size would appear to depend greatly on the situation. A certain-sized stack might be quite safe if built out in the open, where it is exposed to the sun and wind. On the other hand, the same stack built under the lee of a plantation or other shelter might fire. As already mentioned, the stack which fired at Moumahaki was a comparatively small one—14 ft. by 26 ft.—but was built on the sheltered side of a plantation, which helped it to retain the heat. There is no doubt that where the material is not quite right it would be safer to stack it in the open, or put the hay in cocks until the main heating is over. Unquestionably the latter system makes the better hay.

Dairy Records.—This subject came before the International Congress of Agriculture, held at Paris last year. The Congress considered that there should be a world standard method of indicating pedigrees and records of purebred stock, and also a standard method for the issue of certificates of origin and health in the case of all such stock.

Agricultural Education.—This subject was discussed at the last meeting of the Board of Agriculture, and regret expressed that so few high schools made provision in their syllabus for a systematic course in agriculture. It was again pointed out that students with a bent towards agriculture and who would be likely to take up the study of agricultural science were placed at a decided disadvantage by the present matriculation syllabus, which had the effect, in practice, of discouraging agriculture at the expense of the study of a foreign language. The measure of advantage gained by a knowledge of foreign languages was fully realized, but the Board was of opinion that the syllabus should be so rearranged as not to cause this to act as a deterrent to students taking up agriculture as a subject. The Board had previously made representations on this point to the University Senate without satisfactory results, but decided to again take the matter up with a view, if possible, of inducing the Senate to reconsider its former decision.

LOSS IN WEIGHT OF STORED APPLES.

R. WATERS, Plant Pathologist, Biological Laboratory, Wellington.

THE further investigation into the cause of apple flesh-collapse this year includes a study of the temperature-humidity ratio—a line of procedure clearly indicated by the work of the past three years. Long running-hours, a low flesh-temperature range, high relative humidity, and unwilted apples seemed to be associated with flesh-collapse in cool store; shorter hours, higher temperatures, lower humidity, and consequent wilted condition appeared to result in greater freedom from the disease. The following questions therefore presented themselves:—

(1.) Was the freedom from flesh-collapse in farm-sheds and other unrefrigerated apple-stores due to the greater drying-power of the surrounding atmosphere?

(2.) Conversely, was the abundant development of the disease among certain varieties in cool store due to the low flesh-temperature range, the high humidity, and feeble drying-power which are often in evidence where the trouble is pronounced?

(3.) Would the alteration of the temperature-humidity ratio of such cool stores to produce a greater drying-power reduce the proportion of flesh-collapse?

(4.) Would the loss in weight of the fruit be a useful measure of the effects of different temperature-humidity ratios, and would such loss be measurable in the first ten weeks of cool storage when flesh-collapse has been shown to be initiated?

Experiments to answer these and other questions were then devised and are now in progress, and it has been suggested that last month's results from the preliminary loss-in-weight experiments should be set out for the information of those who are confronted with the problem of the satisfactory cool storage of apples this season.

RESULTS OF THE PRELIMINARY EXPERIMENTS.

The experiments were made, in two different cool stores concurrently, with several cases each containing exactly 30 lb. of Sturmer apples picked from two different orchards on 2nd and 5th March respectively, and placed in their storage positions within twenty-four hours of picking. After standing for a certain time the fruit was examined for wilt and the loss in weight ascertained. For convenience the results are here expressed on the basis of one bushel case of 40 lb., as follows:—

Storage at a low temperature: 40 lb. of Sturmers in cool storage, with discharge temperatures varying between 31° and 40° F. and relative humidity varying between 66 and 84 hygrometric degrees, lost—(1) at the first store, 9 oz. in eleven days and 13 oz. in twenty days; (2) at the second store, 8 oz. in twelve days and 11·7 oz. in twenty days.

Storage at slightly higher temperature: 40 lb. of Sturmers in cool storage, with discharge temperatures varying between 33° and 42° F. and with relative humidity varying between 70 and 80 degrees, lost—

at the first store, 7·7 oz. in eleven days and 13·7 oz. in twenty days; at the second store, 8·7 oz. in twelve days and 13·3 oz. in twenty days.

Storage at much higher temperature: 40 lb. of Sturmers stored in a packing-room, exposed to the much higher natural temperatures and the natural humidity fluctuations, lost—at the first store, 18·7 oz. in eleven days and 32 oz. in twenty days; at the second store, 16 oz. in twelve days and 27 oz. in twenty days.

Suggestions.

These figures suggest:

(1.) That the study of the loss in weight of stored apples offers great possibilities of affording information of considerable value in cool storage.

(2.) That in the first few weeks it is possible to measure progressively the total drying-effect of a cool store by weekly determinations of the loss in weight of a definite quantity of fruit.

(3.) That it is possible to arrive beforehand at the total loss in weight necessary to produce wilting, so that the liability thereafter of damaging fruit in store by excessive drying may be avoided.

(4.) That under the conditions of this experiment a 40 lb. case of Sturmers could lose 2 lb. of water without being detrimentally affected by shrivelling.

(5.) That certain cool stores, even with a dripping-brine system, do not extract anything like this amount in the first few weeks of storage.

(6.) That the advantage claimed from delaying the cool storage of certain varieties after picking may possibly be due to the far greater loss in weight under outside conditions as compared with that in the cool stores.

(7.) That to remedy this apparent defect in cool store it may be necessary to modify the temperature-humidity ratio so as to increase the drying-power of the atmosphere in the first few weeks of cool storage.

(8.) That the difficulty of effecting a requisite loss in weight may be more pronounced in a wet season, when the incoming fruit is surcharged with moisture and when the packing and cases may be damp or wet; or again later in the season, when the stores are carrying the maximum load of fruit.

(9.) That the relative drying-effects of different cool stores with different running-hours, temperature-ranges, and humidity-conditions—in fact, with different systems and management generally—might be indicated cumulatively and measured and compared periodically by determining the loss in weight of a given quantity of fruit.

(10.) That in a five-thousand-case chamber the extraction of even ½ lb. of water per case in eleven days requires that 2,500 lb. (equal to 250 gallons) of water shall be removed in that time—a fact that demands in a wet system constant reconcentration of the dripping brine, or, in a dry system, much more frequent defrosting of battery-pipes than has hitherto been deemed necessary, and even longer (and intermittent) hours of running in the early part of the storage season.

NOTE.—The foregoing experiments, which were made with immature fruit at a time when the stores were carrying only small quantities of other fruit, are being repeated on a larger scale with mature Sturmers stored in fully loaded chambers.

SEASONAL NOTES.

THE FARM.

CATCH-CROPPING OR FALLOWING.

LAND that has grown millet, maize, turnips, or similar crops, and is required for cropping purposes or sowing down in pasture next spring, should now either be sown in catch-crops to provide early spring feed, or ploughed and allowed to lie fallow during the winter so that frost may mellow the soil. The lighter soils are better sown in catch-crops, as the latter help to control weeds and prevent leaching. On the other hand, stiff wet soils will greatly benefit by a winter fallow. For fallowing, the ploughing should be deep and the furrow thrown up as rough as possible, so as to expose the greatest surface to the weather. Among suitable catch-crops are Black Skinless barley, Algerian oats, and Cape barley (2½ bushels to 3 bushels per acre), or a mixture of Cape barley, rye-corn, and oats (1 bushel of each per acre). The Black barley will come away the quickest and provide the greatest amount of fodder. In several tests both cattle and sheep have shown a very marked preference for the Black barley as against Cape barley or oats. If a heavy crop of green material is desired for cutting and feeding out during August and September, Ruakura or Garton oats should give good results.

WINTER WHEAT.

On most of the wheat-growing lands of Canterbury and North Otago the month of May should mark the commencement of sowing. It is true that on specially rich soils very early sowing tends to produce an excessive growth of straw, the result being difficulty in harvesting due to lodging of the crop. On the whole, however, it is desirable to start sowing as early as possible in May.

Pickling for Smut.

This precaution should never be neglected, and the formalin treatment is recommended. When properly carried out this does not affect the germination of the seed. Bluestone, on the other hand, while no doubt an excellent smut-preventive, does have a harmful effect on the germination. Exhaustive tests in the use of the formalin method for the control of bunt (stinking smut of wheat) have been conducted in England, and the treatment endorsed in the *Journal of the Ministry of Agriculture* is as follows :—

(1.) The seed in a heap is sprinkled with diluted formalin solution (1 pint formalin to 60 gallons water = 1 fluid ounce to 3 gallons water). Two gallons of the solution must be used to every 4 bushels of wheat. The seed is shovelled over and over until all the grains are wetted ; the solution must not be allowed to form pools under the heap in which the grains might soak. (2.) The heap of wetted seed is covered over for four hours (not longer) with sacks which have been soaked in the diluted solution ; the sacks should be uniformly wet, but not dripping. (3.) The heap is then spread out to dry in a thin layer on a clean floor. If the floor has previously been used for untreated wheat it should be wetted all over with the diluted formalin solution, and allowed to dry before the

treated seed is spread on it. (4.) Precautions must be taken to prevent the recontamination of the treated seed—*e.g.*, sacks which have held untreated contaminated wheat must not be used for treated seed unless they have been soaked in diluted formalin solution or boiled in water. (5.) The treated seed when dry should be sown as soon as possible.

Another method used successfully is to soak the wheat for seven minutes in the solution prepared as above, each sack being divided into two equal parts to facilitate handling. The wheat is allowed to drain after soaking.

For those who still prefer the bluestone treatment the following is recommended: Dissolve 1 lb. copper sulphate (bluestone) in 5 gallons water (using wooden or stoneware receptacle), and, spreading the grain on a clean floor, sprinkle at the rate of 1 gallon of the solution to 4 bushels of grain. Mix thoroughly and sow as soon as dry enough to handle satisfactorily.

The foregoing treatments have no effect on loose smut of wheat, and it is very necessary to get samples free from this pest for seed purposes. Varying strengths of formalin and bluestone solutions are recommended by different authorities, and it must be remembered that, particularly in the case of bluestone, a too strong solution has considerable harmful effect on germination. Dry-dusting methods with copper carbonate, &c., have not yet been adopted in New Zealand, but experimental work is proceeding.

ROOT CROPS.

Mangolds, carrots, and swedes are still growing, but the latter, where sown at the normal time, will be approaching maturity in May. This crop should be carefully watched for dry-rot, which shows up on the outside of the bulb. If much of this is present, feeding-off should be pushed ahead, as it is better to put the swedes into live-stock, even if somewhat early, than allow them to decay. If a swede crop is sound at this period it will usually keep well through the winter.

Harvesting Mangolds.

The mangold crop will be fit for harvesting in May and June. Where the area is large and labour comparatively scarce the roots can be left standing till within a couple of weeks of feeding, when they should be pulled and left on the surface. This practice, however, is safe only in districts where a mild winter is experienced, and storing is the better plan. It is quite possible to harvest mangolds too early, which leads to imperfect ripening and gives them a tendency to shrink unduly: it is best to wait till the leaves become limp. Provided the soil is not sticky at the time, trimming is unnecessary and even undesirable, as it may cause bleeding. The mangolds should be pulled by the left hand, the tap-root cut off by the right hand with a knife, and the top severed as the root is thrown into the dray or on to the heap. An experienced man can make very quick work of this. Some growers use a home-made implement shaped after the fashion of a snow-plough to push the roots out of the ground and into rows, the tops having been previously fed off with broken-mouthed sheep or chopped off with a sharp hoe.

Storage clamps or pits should be situated on dry ground and fenced off from stock: 5 ft. high on a basal width of 5 ft. is a convenient

size. Larger dimensions are often used, but the roots should then be left for several days in the paddock to avoid undue sweating in the clamp. In any case the clamp should not be completely covered for a week after it has been built. Clean wheat-straw is the best covering-material, but oat-straw, bracken-fern, and hedge-trimmings are also useful. A few sods or shovelfuls of earth should be put on to prevent high winds blowing the straw off, and in cold districts this earth can be made into a solid covering against frost. If Long Reds are grown with other varieties the clamp should be arranged so that the Long Reds may be used last. Owing to their superior keeping-qualities they are valuable for pig-feeding, &c., till the end of December.

As a rule, mangolds should not be fed before the middle of July; unripe, they are not only a wasteful but a dangerous food. They are of greatest value after midwinter, and when calving and lambing have commenced.

LUCERNE.

The winter months are the resting-period for the lucerne-plant, and in no circumstances should a stand be heavily grazed during that period. A few calves or other light stock may not do a great deal of damage, but the ideal practice is to give the stand a light cultivation if the land is dry enough, and let it run through the winter with a little rough growth on it. If the land is wet do not cultivate. Lucerne is generally grown to provide heavy crops of hay, ensilage, or green feed during the summer, and if it is knocked about during the winter the returns are greatly reduced.

Established stands, whether broadcast or in rows, if not already cultivated, will benefit greatly by earlier autumn working. This should be done thoroughly to a depth of 4 in. or 5 in. Where stands have been sown in 7 in. rows the advantage of this method over actual broadcasting is apparent at time of grubbing. The Planet Jr. No. 42 is a very useful implement for this class of work.

POTATOES.

The main crop should now be lifted before cold wet weather sets in. It is of great importance that the tubers be dug in a dry, clean state; if at all wet they should be left for some hours to dry before being bagged.

There is evidence of the potato-moth (*Lita solanella*) being rather plentiful in South Canterbury this season. Tubers containing the grub of this insect should be boiled and fed to pigs, and not pitted with sound ones. In cases of badly infected crops which are being used for pig-feed the pitting should not be done until after a few good frosts, which will effectively kill the grubs.

ARTICHOKES AND PIGS.

Considerable areas of artichokes are now grown for pig-feeding. They may be stocked any time now, but, if not required, stocking may be deferred until June or July, and feeding may continue until the end of August. In feeding-off it is not desirable to make the breaks too small, as they become badly puddled if the weather is wet; ¼ acre for twenty-five to thirty pigs is quite small enough. Feeding should continue until the pigs appear to find difficulty in getting

sufficient food. If removed then there will generally be plenty of seed for the next crop. It is, however, just as well to fence off a small corner to preserve seed, in case it is required to fill up gaps the following season. Pigs on artichokes should be provided with a dry bed. A fair crop should carry sixty store pigs per acre from eight to ten weeks.

—*Fields Division.*

THE ORCHARD.

GENERAL WORK.

THE end of the present month will see picking almost completed, only a few late varieties remaining to be gathered. If mid-season varieties have been held other than in cool store a careful watch should be kept to enable them to be placed on the market to the best possible advantage. All fruit held for some time after picking should be repacked before it is placed on the market, otherwise the buyer may have cause to complain, and this is not conducive to good business.

The close of the picking season affords a good opportunity for cleaning up in and around the orchard and packing-sheds. If it has been necessary to use props these should be gathered up and placed in a heap in one corner of the orchard, where they will be in readiness for the following season if required. Picking-cases, if not holding fruit, should be stored away in a shed ready for future use. All fruit rejected and unfit for the market or by-products should be cleaned up and disposed of, as such stuff becomes a source of danger from a disease point of view, besides being unsightly.

At this time of year it behoves every grower to take a retrospective view of the past season's workings, while at the same time looking forward to the coming season. All spraying results should be examined thoroughly. If there have been failures, investigation should be made to try and discover the reason. Where success has been achieved by the season's operations it must never be taken for granted that the same programme can be followed in detail the following season with the same results.

If spraying for the control of woolly aphis, as mentioned in last month's notes, has not been carried out no time should now be lost in making the application.

The heavy rains experienced during the late autumn and winter of last year should remind many orchardists of the necessity for making ample provision for the thorough drainage of all surface water. At the close of the picking season it is often good practice to plough the land, turning it towards the trees and thereby leaving an open furrow down the centre between each row of trees. Where water is liable to lie this will allow it to drain away freely. If cover-crops are growing, such ploughing is not always practicable, but in such case a furrow can be drawn at any place where there is danger of water accumulating. If this is done and outlets into proper channels are provided there will be little or no danger from surface water.

Preparation of land for the planting-out of trees should be pushed on with all speed before the winter rains set in.

—*L. Paynter, Orchard Instructor, Christchurch.*

CITRUS-CULTURE.

In bearing groves where fungicidal sprays have been applied there is little else of a routine nature to be done during the coming month other than the usual harvesting operations.

Where citrus-trees are grown on any class of gum-land much benefit is derived by the growing of leguminous cover-crops such as blue lupins. Growers are recommended to sow this crop wherever possible, for the purpose of improving the mechanical condition of the soil and for the addition of humus and nitrogen. May is one of the most favoured months for carrying out this work, and, provided weather conditions are suitable, growers concerned are advised to lose no time in its execution. A small dressing of superphosphate or basic slag at the rate of about 1½ cwt. to 2 cwt. per acre at the time of sowing is recommended. For preference, sowing should be carried out with an ordinary farm drill.

Although there was not very much damage done in citrus orchards in the Auckland District by frosts last season, it is noticed that some growers have not yet completed the work of the removal of the affected portions. This work demands immediate attention.

STRAWBERRY-GROWING.

In cases where it is intended to lay down new beds of strawberries this season the work of preparation of the sites for planting out should now be well in hand. In the Auckland District new ground is usually preferred, owing to the absence of weeds on such. The soil which is considered to be most suitable for the cultivation of apples is generally found suitable for the growing of strawberries. Good drainage is essential, and deep tillage is necessary in the preparation of the soil. A very heavy soil or stiff clay is quite unsuitable for cultivation of the strawberry, as is also a very sandy soil which dries out too rapidly during the hotter part of the season. It is usual in the Auckland District to apply artificial fertilizers rather than to use stable or farmyard manure. Although, as above stated, new soil is generally preferred for the planting-out of new strawberry-beds, on account of the absence of weeds, it must be remembered that prepared soil will often give a much better result—that is, land which has been well worked the previous season and sown down in some leguminous plant, thus adding nitrogen to the soil. After the necessary cultivation has been completed the ground should be well rolled before the planting is undertaken, after which the drills may be made and manure applied.

Planting out is generally done when there still remains some warmth in the soil—namely, the latter part of April—in which case it is necessary to keep the surface soil well stirred whenever opportunity permits throughout the winter. In some cases early spring planting is preferred, but should the weather become very wet at planting-time the work is often handicapped and growth is delayed, whereas with the April planting the plant has sufficient time for good root-formation, and when the warmer weather sets in in the early spring growth commences immediately.

Regarding the selection of plants, Marguerite remains the favourite variety in the Auckland District, while in the Southern districts

Laxton's Noble and Melba hold pride of place. Others in favour include Phenomenal and Duke of Edinburgh. Before making their final selection, intending growers are advised to make thorough inquiries regarding several strains which are being offered, and only those strains which are considered to have proved themselves good fruiters should be planted.

—J. W. Collard, Orchard Instructor, Auckland.

POULTRY-KEEPING.

THE PULLETS AND WINTER-EGG PRODUCTION.

Now that the dear-egg season is at hand the poultry-keeper's chief concern will be the care of his pullets—studying their requirements and making the conditions as ideal as possible in order that a maximum result may be secured. If this desired end is to be attained there must be no half-measures in the chain of management. Obviously if a pullet is to produce her out-of-season product in good number she must be given every assistance to do so. In the first place she must be made comfortable, as only in this condition can she be expected to lay heavily. This implies that the house must be roomy and well ventilated, but without draughts, and partly opened up in front in order to admit as much sunlight as possible. The floor should be well littered with straw. The grain food should be well scattered in the straw as a means of compelling the birds to exercise in finding the grains. Above all, as a preventive against colds, it should be seen that there are no cracks in the sides or back walls. Even the partitions in the houses near where the birds are roosting should be free from draughts. The walls should be tested for draughts at night with a lighted match.

Among many poultry-keepers there is a tendency to wait till colds make their appearance and then to resort to curative measures. This is a mistake. Similarly to most other troubles affecting poultry, prevention is the only safe course of dealing effectively with this one. It may happen that only one or two birds contract a cold as a result of sleeping near a crack in the wall, but usually from these the trouble will rapidly spread through the flock. Once a flock of pullets become affected with colds their egg-yield rapidly declines, and in spite of all that is done for them they will bear an unkempt, miserable appearance. Thousands of winter eggs are lost annually from no other cause. Not only this, but colds are the forerunner of roup, and once this dreaded disease gains a foothold there is no telling when it will be stamped out.

Cleanliness is another important preventive factor against disease and insect pests. The droppings should be frequently removed, and at frequent periods the perches given a good application of kerosene or a strong disinfectant.

Food-quality and the Ration.

The poultry-keeper should make sure that the food supplied is of the best possible quality quite irrespective of cost. With any class of poultry it is always poor economy to feed damaged or musty food because it is cheap. Especially is this the case with pullets at this

period of the year. They will simply refuse to eat such food (unless, of course, forced to by hunger), and obviously a declining egg-yield will result. With eggs selling in the region of 3s. a dozen it will pay to feed nothing but the best, and as much as the birds can consume of it. There is no danger of overfeeding the laying bird with food of the right quality, provided she is given ample opportunity to exercise.

The morning mash may consist of two parts of pollard to one of bran by measure. This should be made as appetizing as possible by moistening it with meat soup, skim-milk, &c. When these liquids are not available boiling water should be used. A mash moistened with the latter will be much better relished by the birds than when cold water is used. Where a good grade of pollard is not available (much of it these days is more like bran than the genuine article) a mixture of one part of finely ground good-quality wheat to two parts of bran can be depended upon to give better results than can be obtained with inferior pollard. The mash should be mixed to a crumbly consistency, not sloppy. Feed only what the birds will pick up clean in, say, twenty minutes. If mash is left before them at all times they will eat this and fail to take the necessary exercise by scratching for the grain ration in the litter, in which there should always be odd grains of food for the birds to fossick for.

In the evening and well before dark give a full meal of grains, such as equal parts of wheat, oats, and maize. It is always a good plan to give more at this meal than the birds require, as what is left will induce them to scratch and keep busy when they leave the perches in the morning. If it is observed that one of the grain foods mentioned is being left it should be fed in a reduced quantity.

Forcing-food.

To secure a maximum winter-egg yield a forcing element must be included in the ration. This denotes highly nitrogenous substances such as meat, meat-meal, blood-meal, milk, &c. While a forcing-food is specially demanded for the manufacture of the artificially stimulated egg-product of the modern fowl, it is nevertheless always best to chiefly feed this separately, so that each bird may only take what it needs. Nature will usually guide it in this respect. When these rich foods are included in the morning mash, and the birds are compelled to eat more of them than they require in order to secure a meal, ovarian troubles such as protrusion of the oviduct are almost sure to follow. In a general way, where boiled meat is available it may be fed in the proportion of 1 oz. to each bird per day. Where meat-meal is used as a substitute it may be judiciously supplied in the morning mash in the proportion of, say, 6 per cent. of the entire mixture. It may also be available in a separate receptacle for the birds to pick at, and in this way those birds which crave for a larger share will be able to secure it. It will generally be found that the greater the layer the greater will she crave for animal food.

Naturally, if it is observed that ovarian troubles are making their appearance and that many shell-less or double-yolked eggs are being produced, the forcing-diet should be reduced accordingly, as this indicates that the birds are eating more of the forcing-food than is good for them.

Green Food, Grit, Lime, and Water.

Green food is another important matter in the ration of the laying bird. It should be provided every day with a free hand, otherwise the digestive system will become deranged, and the health of the birds will rapidly decline as well as the egg-yield.

Sharp gravel-grit is also an essential for the well-being of fowls. Its chief function is assisting the grinding process of the grains in the gizzard. Lack of hard grit is a common cause of digestive troubles and unthrifty flocks.

Lime is also necessary to provide egg-shell-forming material. A good way of supplying lime is in the form of crushed fresh oyster or other sea shell. It is a mistake to mix grit and shell together, or to have them in a small, narrow receptacle. The birds should have free access to these materials in order that they may be given an opportunity of picking up the pieces they most desire.

Clean fresh water should be available to the birds at all times. It should be remembered that an egg contains about 60 per cent. of water, so that neglect to keep the water-vessels filled will obviously mean a falling-off in eggs. Where milk is available it may be given in large quantities to drink at this period of the year. There is nothing better as a substitute for meat and for promoting egg-production. If there is any doubt about this the poultry-keeper should try one pen of birds with milk and another without, and watch results.

Finally, it should be always remembered that winter eggs are an artificially stimulated product, and unless artificial methods of management are resorted to in the way of good housing, plenty of nourishing food, and careful management the best bird ever bred cannot be expected to produce them.

—*F. C. Brown, Chief Poultry Instructor.*

THE APIARY.

UNITING COLONIES.

THE presence of weak hives in the apiary must be avoided as far as possible. During the warm autumn days these colonies rarely escape the attention of robber bees, and are easily molested. When once they are attacked the beekeeper will find it extremely difficult to save them, and eventually they will get robbed out despite his efforts. It is far the better plan to unite the bees with a stronger colony than to run the risk of unsettling them in the dormant season through the encouragement of wholesale robbing. A simple method of uniting colonies was explained in the February issue of the *Journal*.

COVERS.

With the approach of the rainy season it is advisable to make a complete examination of the hive-covers in use. Altogether too little attention is paid to making the covers watertight, and neglect in this direction leads to winter losses. No amount of labour should be spared in saving the bees from exposure and dampness, and by so doing warding off the large annual losses that occur through neglect. There is no excuse for the beekeeper neglecting to protect his bees, and he

will find in the long-run that a small expenditure on some suitable waterproof roofing-material will doubly repay him, and will be the means of saving colonies that would otherwise be lost. Bees must be kept dry. An examination made of colonies where proper protection is not provided will reveal the presence of large quantities of propolis. Usually this is collected to prevent the penetration of external moisture, and it is noticeable that it is gathered freely in the autumn months. Where adequate protection is provided the bees are to a large extent saved the labour of collecting the propolis, and by providing dry roofs the beekeeper is assisting them. In the case of roofs that are cracked do not attempt to tinker with them, but cover entirely with some waterproof material. In the long-run metal coverings are the cheapest and the best. Good zinc or galvanized iron makes ideal covering, and will last for years. Quite a number of beekeepers are now using ruberoid or similar materials with very good results. While not so durable as metal, they serve the purpose admirably, and with careful treatment will last for a number of seasons.

SPARE SUPERS.

Where extracted combs have been placed on the hives for the bees to clean up, these should be removed and the bees confined to as small a space as possible consistent with the size of the colony. It may be necessary to leave some of the supers on during the winter months, and these can be dealt with in the spring. Do not leave the bees more space than they require, as it will be found that they will desert the lower supers and cluster at the top for warmth.

MATS.

See that each colony is provided with one or two good mats during the winter months, to keep the bees as warm as possible. Mats should be cut to fit exactly on top of the frames, and may be made from clean sacking or canvas. Sugar-bags or cornsacks make excellent mats and are easily procured. Wood mats are adopted by some beekeepers, and, if desired, may be secured at a moderate cost from dealers in bee material. In districts where the bees do not bring in a great deal of propolis wood mats are effectual. On no account use calico mats, as these afford practically no warmth.

WEEDS.

The hives should be kept clear of all weeds, so that the flying bees may have free access to the entrances. Many bees are lost by striking growing obstacles on returning to the hives. For the next few months, when the air is charged with moisture, it is important that plenty of air and as much sunlight as possible should penetrate beneath the bottom-boards. In damp situations place the hives sufficiently high from the ground to avoid the dampness. Old bricks or concrete blocks make admirable supports for the bottom-boards. Make sure that the hives have sufficient cant towards the front before the winter rains set in. The presence of much moisture on the bottom-boards will be the means of much loss to the beekeeper, and, in addition, cause the hives to become sour and foul-smelling.

SHELTER.

Where the hives are exposed it is essential that suitable artificial shelter should be erected. Brood-rearing must be encouraged until a

late date, and this will not be carried on by the bees if there is a lack of shelter. It is necessary to prevent the keen driving winds from gaining access to the hives, and the consequent bad effects of chilling the brood. In most districts there is an abundance of manuka scrub, and this affords capital shelter when erected in the form of a breakwind. On no account place hives under high evergreen trees with the idea of affording shelter. This is one of the worst locations, as the trees prevent the entrance of the sun's rays, and there is invariably a cold draught between the trunks.

CARE OF COMBS.

Good extracting-combs are the most valuable asset the beekeeper possesses next to his bees, and great care should be taken to secure them from the ravages of the wax-moth and mice. Hundreds of combs are destroyed annually through carelessness, and this can be prevented by attention to small details. Mice destroy the combs to gain access to the pollen and honey, and render the best combs foul and distasteful to the bees. Combs can be stacked in a mouse-proof room or in supers tiered one above the other. Queen-excluders may be utilized to keep mice out of the combs, and in the absence of close-fitting roofs are a complete success. If the presence of the wax-moth is detected the tiers of combs should be fumigated. Bisulphide of carbon is effective in destroying insect-life, but should be used with great care, as it is highly inflammable. Prevention is better than cure, and a few moth-balls placed in the supers will prevent the attack of the moths.

—E. A. Earp, Senior Apiary Instructor.

THE GARDEN.

VEGETABLE-CULTURE.

As soon as the asparagus foliage ripens, and before the seed drops, it should be cut down and removed. Care should be taken to cut it just below the surface of the ground, and so avoid the awkward stubble that is sometimes seen. Clear the beds of weeds by light forking or hoeing. Winter rhubarb should now be ready for moderate pulling. Early peas may be sown in warm localities.

GARDEN-MAKING.

While the best time for garden-making is the autumn, if the work is at all extensive it has frequently to be left till winter, when more time is available. Thorough preparation is so important that such a delay is to be preferred to making a hurried job earlier in the season.

Shallow-worked lumpy ground with half-rotted turf, or a bad infestation of couch-grass, docks, or other weeds, is too often the condition the grower has to face when starting a crop in spring. Satisfactory results can be obtained only from land that is clean and deeply cultivated, well manured, and in good tilth. These conditions will be obtained by different methods, each circumstance requiring special consideration; but, whatever the method, considerable time and labour are needed. Hurried preparation late in the season, followed immediately by the sowing or planting of the crop, accounts for most of the disappointing results that are met with.

If the area to be dealt with is large and in grass it may be skim-ploughed now and allowed to remain, say, for six weeks or two months, until the turf is thoroughly rotted. It should then be cross-ploughed deeply and subsoiled. Such harrowing as may be required should then follow.

If the section is small and unsuitable for ploughing it is usually best dealt with by trenching. To do this, open a trench at one end across the full width of the section, making it rather wide and about 1 ft. deep or to the top of the subsoil. The soil thus removed should be taken to a position convenient for filling the final trench. Now dig the bottom of the trench over, but do not lift out the soil. Skim the vegetation from a similar width adjoining, and lay it on the bottom of the trench just opened. Proceed to open trench No. 2, and in doing so fill trench No. 1, and continue in this way till the job is completed. Such methods will secure the necessary deep cultivation and tilth. As seedling weeds appear, put the hoe over the ground in fine weather, and by the time the planting season arrives the crop will start under the best possible conditions.

There is still the matter of manuring to consider. It is the custom among market-gardeners to use very large quantities of manure—quantities far in excess of the theoretic needs of the crop. Different soils and different crops require different treatment; the successful grower must study this matter very closely. The subject is gone into fully in the *Journal* for June, 1923, page 372. At this season the slower-acting organic manures may be incorporated with the soil when trenching or ploughing; or if the ground is already rich or inclined to be sour an application of 1 ton of lime to the acre would be an advantage. It should be broadcasted and harrowed in. The application of the more soluble manures is best left till the spring.

These are the secrets for growing successful crops, and poor preparation is the cause of most of the disappointing results. Such preparation as detailed above is specially necessary in the case of crops that are to remain in the land for some years, such as asparagus, rhubarb, strawberries, &c.

It is usual to select naturally well-drained land for garden purposes, but should the land be at all waterlogged at any time it must be drained and the drainage maintained in working-order.

LAWNS AND FLOWERS.

The winter management of lawns is important. Most lawns could receive more rolling with advantage, and an application of basic slag now would benefit many plots. Lime should be applied with caution, owing to its tendency to encourage clovers. The turf will be all the stronger if the grass is allowed to grow rather longer than usual during the winter months.

Lift gladiolus bulbs as soon as the foliage withers; ripen the bulbs off and store them in a dry place. Narcissus bulbs will be making growth, and may be assisted where necessary by the application of suitable manures. Pansies, stocks, wallflowers, &c., for spring blooming should now be well established in their permanent quarters. Keep them clear of weeds, and fill up any gaps that occur.

—William C. Hyde, Horticulturist.

NEW ZEALAND INSTITUTE OF HORTICULTURE.

THE following notes are contributed by Mr. George A. Green, honorary secretary of the Institute :—

The close of March, 1924, seems to be a fitting time to review the work in connection with the organization of the Institute of Horticulture. During the year the provisional committee has registered the Institute, and quite a large number of those interested in horticulture, scattered over the Dominion from the north of Auckland to Invercargill, have signified their intention to link up with the movement. The New Zealand Association of Nurserymen has passed the necessary resolution for affiliation, while the New Zealand Fruitgrowers' Federation is contemplating a similar move. Applications for membership have also been received from some half-dozen horticultural societies and district fruitgrowers' associations. Addresses have been delivered by the honorary secretary in some twelve different centres.

Among the practical work of the year has been the continuation of the bud-selection work by the Teviot Fruitgrowers' branch of the Institute. Up to 28th February, 1924, about sixty thousand certificated buds of the six leading varieties of apricots recommended for commercial planting have been sent out to the fruit-tree nurseries for propagation, and it is estimated that for this year's planting season 90 per cent. of all the young apricot-trees available are from the selection committee's wood. Investigation continues in several centres into the relative merits of certain stone-fruits, while in Tauranga and Auckland it is hoped shortly to start citrus bud-selection in connection with commercial citrus-culture.

A distinct advance has recently been made in connection with the development of the Institute by the formation of committees at both Dunedin and Christchurch, with a view to establishing permanent district councils of the Institute at both the southern centres. The Dunedin chairman is Mr. T. K. Sidey, M.P., and the committee includes Mr. David Tannock, F.R.H.S., and several leading citizens. At Christchurch a representative committee was formed with Dr. C. Chilton, Rector of Canterbury College as chairman. The need for horticultural education appealed to the gatherings at both centres, and the hope was expressed that a school of horticulture might be speedily established. At the moment movements are afoot with the object of starting district councils of the Institute at Auckland, Palmerston North, and Wellington. At the latter centre Dr. L. Cockayne, the distinguished botanist, has associated himself with the movement, and has placed his services at the disposal of the council of the Institute.

Much remains to be done, but the progress made must be considered very satisfactory. Given loyal support and the necessary financial assistance to enable the organization to be carried on to a successful issue, we may soon hope to see the New Zealand Institute of Horticulture taking its rightful place in the activities of the Dominion and exercising its functions in connection with higher horticultural education.

INVENTIONS OF AGRICULTURAL INTEREST.

APPLICATIONS for patents, published with abridged specifications in the *New Zealand Patent Office Journal* for 6th and 20th March and 3rd April, 1924, include the following of agricultural interest :—

No. 48428 : Milking-machine milk weighing and sampling apparatus (C. M. Wright, Manunui). 49546 : Seed-sower (A. H. Constable, Penshurst, England). 49742 : Scythe-stay (W. T. Thompson, Tariki). 51010 : Rabbit-exterminating apparatus (F. W. Parker, Box Hill, Victoria). 51273 : Soil-cultivating implement (D. A. Dunn, Gore). 51369 : Honey-extractor (W. Herrod-Hempsall, Luton, England). 51382 : Milk-cooler (C. F. Vincent, Huirangi). 51447 : Milk-agitator (L. Kjar, Masterton). 49783 : Plough (D. M. McLaren, Pataroa). 50237 : Milk-agitator (D. MacMillan, Clandeboye). 51075 : Milking-machine pulsator (C. T. Newton, Merino, Victoria). 51459 : Milking-machine teat-cup (G. M. Wallace, Hamilton East). 49743 : Milking-machine teat-cup (W. T. Thompson, Tariki, and C. J. Twigg, Lepperton). 51284 : Wool-bale-stacking device (W. Webb, Mataimoana). 51291 : Incubator (H. J. L. Williams, Spreydon). 51427 : Meat treatment and storage (J. A. Linley, London). 51474 : Milking-machine pulsator (J. G. Lamb, Melbourne).

Copy of full specifications and drawings in respect of any of the above may be obtained from the Registrar of Patents, Wellington, price 1s.

ANSWERS TO INQUIRIES.

IN order to ensure reply to questions, correspondents must give their name and address, not necessarily for publication, but as a guarantee of good faith. Letters should be addressed to the Editor.

BREEDING FERRETS.

"FERRETS," Maungatautari, Cambridge :—

I have four female ferrets that I would like to breed from. Will you kindly give me a few particulars as to the length of gestation and proper handling of young in the early stages, also state if there is any particular breeding season? I keep ferrets solely for assisting me to combat the rabbit pest, and want to breed my own instead of having to buy others to replace losses.

The Live-stock Division :—

The gestation period of ferrets is six weeks, at the end of which time the young are born, hairless, blind, and deaf. There are usually six to nine in a litter, two litters being produced each year, the second commencing as soon as the first have been weaned. In New Zealand the bitch ferret comes on season about October or November. The period of œstrum lasts about three days, during which time the vulva is much swollen and protuberant. When about to bring forth young the female should be given a good straw bed, and then left as much alone as possible till the young are about ten to fourteen days old, as she has a tendency to eat her offspring if she is worried by being watched or by the place being cleaned out. The eyes of the young do not open for about twenty-eight days. The male ferret must, of course, be separated from the female at this time. Ferrets require a good closed-in pen with straw for sleeping-quarters and a yard in which they can feed and get exercise. If not kept scrupulously clean they are liable to contract distemper or get sore feet or become lousy. As soon as the young are old enough they should be handled and thus tamed for their work of rabbiting. You will probably find that ferrets kept in captivity do not breed after the first year as regularly as expected.

RENOVATING A PASPALUM-DANTHONIA PASTURE.

"SUBSCRIBER," Wayby :—

Please advise me how to renovate a worn-out pasture, principally paspalum and danthonia, without ploughing.

The Fields Division :—

You are advised to well disk-up the paddock in July. Then harrow, roll, and sow a mixture consisting of—8 lb. perennial rye-grass, 3 lb. Italian rye-grass, 2 lb. white clover, 3 lb. red clover, 1 lb. subterranean clover, and 1 lb. Lotus major. Mix the seed with 3 cwt. of a mixture of basic slag and superphosphate in equal parts. Follow the sowing by light harrowing.

HARES AND OPOSSUMS IN THE ORCHARD.

"SUBSCRIBER," Lower Hutt :—

I am pestered with hares and opossums, and would be obliged if you could advise me how to get rid of them so as to be within the law. I have an orchard, and the loss is very serious, as they strip the trees of nearly all the fruit, break boughs, &c. My boundary-fence is adjoining the bush.

The Horticulture Division :—

Hares are best kept out by putting up a wire-netting fence. In some places growers are able to protect their trees by spraying the lower parts in spring with a strong lime-sulphur wash with a little extra lime added, but in such districts attacks are practically confined to late winter and early spring, when possibly feed for the hares is scarce. The Animals Protection and Game Act,

1921–22, allows opossums to be taken at any time without license in any orchard registered under the Orchard and Garden Diseases Act, 1908, or within half a mile thereof, by the occupier of such orchard or by any *bona fide* employee of the occupier. All skins so taken and which it is proposed to dispose of must be stamped by an authorized officer and a royalty of 1s. paid thereon within one month from the date on which the skins were taken. No person may dispose of opossum-skins for gain unless sold to or by a licensed broker. Skins retained for a person's own use must also be stamped and a royalty of 1s. paid thereon within one month from the date on which such skins were taken.

REARING A MOTHERLESS FOAL.

"MOTHERLESS," Highbank :—

I have a foal that lost its mother at the age of two weeks. I have fed it on milk up to now, but have started to give it ground linseed and oatmeal. Will you kindly advise me as to the best and proper manner of feeding ?

The Live-stock Division :—

The following procedure is recommended : To 20 oz. (1 pint) of cow's milk add 5 oz. of boiled water and 1 dessert-spoonful of sugar. Feed this to the foal five times daily, increasing the amount gradually as the animal grows, until it is taking from 7 to 8 quarts daily. One cup of linseed-gruel, made by simmering whole linseed in a little water, may be added two or three times a week. Induce the foal to eat crushed oats by placing a small quantity in a convenient place. The animal should be protected from all cold and wet weather, but during the daytime in warm weather it should be allowed to run on a good, clean pasture. Later on it should be allowed free access to good, clean water. If constipation occurs at any time you could give up to 3 tablespoonfuls of castor-oil, according to the size of the foal at the time.

CONTROL OF FOXGLOVE.

"WEED," Raetihi :—

Will you kindly give me what information you can regarding foxglove ? Will it die out in time ? Is pulling it out the only way of getting rid of a fair quantity of it ?

The Live-stock Division (Noxious Weeds Inspection) :—

Foxglove when once firmly established, especially in bush-cleared lands where logs and stumps abound, is a most difficult plant to eradicate, as it is a biennial and a very free seeder. If it already has a good hold on the land all that can be done (if the land is unploughable) is to pull up or cut down, to prevent seeding, the whole of the plants that appear. This carried out for a number of years should have the desired effect of eventually eradicating the weed. This entails a good deal of work unless done when the plant first makes its appearance. In cutting or pulling the plants the work should be done before the plants are in full flower, as the flowering-period is fairly long and seeds will have matured on the lower stem before the upper portion has finished flowering. When eradication is aimed at foxglove should be dealt with twice yearly : firstly, when the flowering-stems are developing the plant should be pulled up ; and, secondly, during the blossoming-period any standing should be cut down or pulled up. Any small plants that are not in flower should also be pulled up or chipped out. If it is dealt with in the early stages of its spread it may be eradicated in a few years by these means, but where it has infested the land for a number of years and has been allowed to deposit its seed young plants will keep springing up for several years. Statements have been made that if left alone for a number of years foxglove will eventually die out, but we would certainly advise you not to wait for such a result, whether the plant has been declared a noxious weed or not. In districts where it has been declared to be a noxious weed by the local authority the Noxious Weeds Act requires that it shall be cut down and kept cut down, or grubbed or pulled up to prevent the spread thereof by seeding or otherwise.

WEATHER RECORDS: MARCH, 1924.

Dominion Meteorological Office.

GENERAL SUMMARY.

THE outstanding features of the month of March were warmth and high humidity, especially in the North. In the latter part of the month drought was experienced in many parts of Otago, with considerable heat.

It is several years since one month has shown such a succession of ex-tropical disturbances as have lately dominated weather conditions in the North. The South, on the other hand, was really affected by only one westerly disturbance, between the 7th and 10th, though two others passed southward of the Dominion on the 13th and 19th. Barometric pressure was mostly above normal over the Dominion from the 1st to the 7th and from the 16th to the end of the month.

The first few days of the month were generally hot and humid, and on the 6th some remarkable rain fell while the barometer was still high, electrical conditions being evidently responsible for the downpours. Between the 7th and 16th barometric pressure was lowest in the North, and strong north-east to south-east winds ruled. Heavy rain and thunderstorms were experienced on the 10th in several parts—for example, at Hawera, 4·20 in. were registered at the post-office, 5·37 in. at Argyle Street, and at the trout-hatcheries, two and a half miles away, the fall amounted to 9·09 in.

There had been a very dry period in Canterbury, and the 9th was exceptionally hot, 89·8° F. being registered at Christchurch. This was followed by thunderstorms on the 10th, and some very beneficial rains of 1 in. and upwards occurred. In the high lands of the province the rainfall was abundant; the Hanmer observer remarks that the month was exceptionally wet and that there was a total absence of high winds. Other parts did not escape gales, and one in Cook Strait on the 11th was described in the Press as "the worst for thirty years."

On the 11th a tremendous downpour occurred in the vicinity of Napier. At Eskdale the gauge overflowed, but 17·90 in. of rain was measured in one day; 13·56 in. at Tutira, and 17·15 in. at Riverbank. At Napier the observatory (which is at present somewhat sheltered) recorded 8·03 in., but 10·90 in. was registered at the residence of Mr. J. H. Coleman. These falls were very local and due to the influence of a thunderstorm. At Hedgely, Eskdale, thunder and lightning were observed at 5 a.m. and continued at intervals until dark. Mr. T. P. Clark (the observer) reported that the River Esk rose very quickly to about 4 ft. or 5 ft. higher than previous records, and that a creek running into it had backed up to 25 ft. above normal. The damage done by the floods was serious to roads and bridges, and there were losses of stock; but Hastings, Maraekakaho, and other places in the vicinity escaped the cloud-burst (any excessive and prolonged fall in a locality is described as a "cloud-burst").

Total rainfalls were generally above the average, but below it in many parts of Canterbury and on the west coast of the South Island, as well as in the whole of Otago.

—*D. C. Bates, Director.*

RAINFALL FOR MARCH, 1924, AT REPRESENTATIVE STATIONS.

Station.	Total Fall.	Number of Wet Days.	Maximum Fall.	Average March Rainfall.
North Island.				
	Inches.		Inches.	Inches.
Kaitaia	3·88	10	1·64	3·58
Russell	6·13	16	2·70	3·42
Whangarei	7·33	16	2·16	5·10
Auckland	3·63	16	1·31	3·06
Hamilton	6·11	18	1·73	3·74
Kawhia	5·33	11	2·69	3·12

RAINFALL FOR MARCH, 1924—*continued.*

Station.	Total Fall.	Number of Wet Days.	Maximum Fall.	Average March Rainfall.
North Island—continued.				
	Inches.		Inches.	Inches.
New Plymouth	6·56	13	2·35	3·46
Inglewood	9·53	14	3·48	7·39
Whangamomona	6·48	11	2·10	5·46
Tairua, Thames	9·58	15	4·09	6·73
Tauranga	7·01	15	2·18	4·18
Maraehako Station, Opotiki	4·10	10	1·40	3·90
Gisborne	10·20	17	4·98	4·60
Taupo	2·22	9	0·84	3·53
Napier	10·80	11	8·03	3·40
Maraekakaho Station, Hastings	5·43	13	1·78	3·10
Taihape	7·36	14	2·50	2·69
Masterton	3·36	15	1·07	3·23
Patea	3·80	10	1·69	3·60
Wanganui	2·20	8	1·49	2·60
Foxton	1·44	8	0·34	2·36
Wellington	4·75	13	2·07	3·27
South Island.				
Westport	5·31	13	1·12	5·80
Greymouth	6·64	10	1·58	9·12
Hokitika	6·30	14	1·86	9·72
Arthur's Pass	4·68	7	1·78	5·84
Okuru, Westland	16·26	11	3·24	15·48
Collingwood	8·83	14	2·52	4·19
Nelson	7·20	12	3·72	2·99
Spring Creek, Blenheim	3·26	10	1·20	1·81
Tophouse	4·58	15	1·17	3·44
Hanmer Springs	5·23	14	1·63	2·84
Highfield, Waiau	4·79	11	2·45	3·09
Gore Bay	4·40	10	1.43	2·14
Christchurch	1·56	12	0·46	2·11
Timaru	1·42	12	0·22	2·45
Lambrook Station, Fairlie	1·40	9	0·42	2·58
Benmore Station, Omarama	3·10	8	1·16	2·64
Oamaru	1·55	7	0·76	1·77
Queenstown	1·02	5	0·61	2·63
Clyde	0·81	5	0·42	1·50
Dunedin	1·13	9	0·60	2·99
Gore	1·11	9	0·44	3·23
Invercargill	0·97	14	0·50	3·86

British Market for Peas.—The following report was cabled by the High Commissioner, London, on 5th April: *Peas*—Market for blue is depressed in consequence of heavy arrivals from Japan. Best Japanese hand-picked marrowfats ex store, £20 5s. to £20 15s.; April/May shipments, £19 10s. per ton c.i.f. Tasmanian "A" grade, March/April shipments, worth about £19 10s. per ton c.i.f. New Zealand ex store, slow sales at £16 to £19. English maple plentiful at 55s. to 65s. per quarter. Nominal values ex store of New Zealand maple, 68s. to 74s.; Tasmanian, 87s. 6d. to 92s. 6d., and March/April shipments offered at 77s. 6d. c.i.f.

WINTER FARM-SCHOOLS, 1924.

THE Department has arranged courses of instruction for farmers in the various districts as follows:—

Auckland: (1) At Ruakura Farm of Instruction, Hamilton, 7th to 12th July; (2) at Dargaville, 30th June to 4th July. Enrolment with the Instructor in Agriculture, Department of Agriculture, Auckland.

Taranaki: At Stratford, 23rd to 28th June, Enrolment with the Instructor in Agriculture, Moumahaki Experimental Farm, Waverley.

Wellington: (1.) At A. and P. Show-grounds, Solway, Masterton, 12th to 17th May; enrolment with the Instructor in Agriculture, Department of Agriculture, Palmerston North. (2.) At Central Development Farm, Weraroa, 2nd to 7th June; enrolment with the Farm Manager.

Canterbury: At Timaru, 5th to 10th May. Enrolment with the Instructor in Agriculture, Department of Agriculture, Christchurch.

Otago and Southland: (1) At Invercargill, 19th to 23rd May; (2) at Dunedin, 26th to 31st May. Enrolment with the Instructor in Agriculture, Department of Agriculture, Dunedin.

Details of the respective schools (programme, accommodation, &c.) will be published in the local Press in each case, but any further information desired may be obtained from the departmental officers specified above. Early enrolment is advisable.

STOCKS OF EGGS AND EGG-PULP, ETC., IN STORE.

ARRANGEMENTS have been made for the Government Statistician to obtain returns of the quantities of eggs in shell, egg-pulp, and frozen whites and yolks, held in cold store throughout the Dominion as at 31st March and 31st July respectively each year. The object of the return is to ascertain the quantity of eggs and egg material which it is necessary to store for consumption during the scarce season of production, and to obtain a guide as to the quantity of eggs that can be exported without interfering with the requirements of the local trade.

The return of stocks held in cold storage at 31st March, 1924, is as follows:—Eggs in shell, 44,942 doz.; egg-pulp, 840,889 lb.; frozen whites, 2,618 lb.; frozen yolks, nil.

FORTHCOMING WINTER SHOWS.

Canterbury A. and P. Association: Christchurch, 14th to 17th May.
Southland A. and P. Association: Invercargill, 21st to 23rd May.
Waikato Winter Show Association: Hamilton, 27th May to 3rd June.
Otago A. and P. Association: Dunedin, 3rd to 6th June.
Auckland Winter Exhibition: Auckland, 10th to 28th June.
Manawatu A. and P. Association: Palmerston North, 17th to 21st June.
Wellington Winter Show Association: Wellington, 5th to 12th July.

(Agricultural and Pastoral Association secretaries are invited to supply dates and location of their shows.)

Quarantine of Imported Dogs.—During the past year the period of quarantine of dogs imported from the United Kingdom has been a clear six months at the quarantine station. An amendment to the regulations, gazetted on the 27th March, allows the period of six months to include the time from the date of embarkation of the animal in Britain to its removal into quarantine after arrival in New Zealand.